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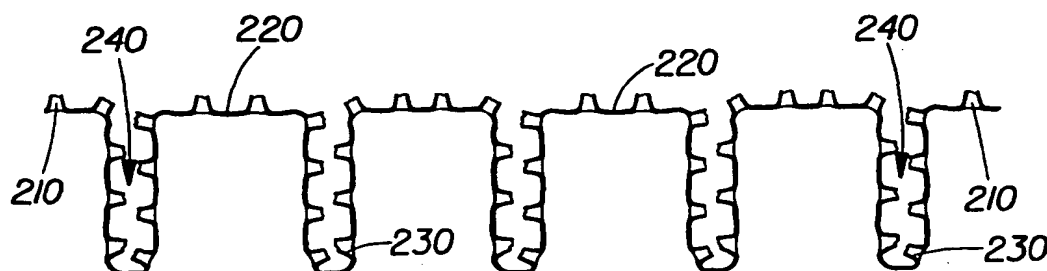
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(54) Title: TEXTURED, MICROAPERTURED WEBS AND ABSORBENT ARTICLES USING SUCH WEBS



(57) Abstract: The present invention relates to a textured, microapertured web formed from a formed film ply which is suitable for use as a topsheet in an absorbent article. One embodiment of the present invention is a fluid permeable web comprised of a polymeric formed film ply having at least two layers, each of the layers having opposed first and second exterior surfaces. The polymeric formed film ply is provided with microapertures placing the first exterior surface and the second exterior surface in fluid communication with one another and the exterior surfaces are comprised of materials that provide a surface energy gradient between the surfaces. One preferred embodiment of the present invention is a multi-layer formed film ply having a first layer, a second layer, where one of the first or second layers is a block copolymer of a polyether and another polymer and the other layer is a hydrophobic layer as defined herein. Methods of producing such webs are also disclosed.

WO 01/76524 A1

TEXTURED, MICROAPERTURED WEBS AND ABSORBENT ARTICLES USING SUCH WEBS

FIELD OF THE INVENTION

This application is a continuation-in-part of pending U.S. application Serial No. 09/344,161 filed by Lee et al. on June 24, 1999. The present invention relates to a textured, microapertured web comprising a polymeric film which is suitable for use as a topsheet in an absorbent article. The present invention also relates to absorbent articles incorporating a topsheet according to the present invention.

BACKGROUND OF THE INVENTION

It has long been known in the field of disposable absorbent articles that it is extremely desirable to construct absorptive devices, such as disposable diapers, sanitary napkins, incontinent briefs, bandages, wound dressings, and the like, presenting a dry surface feel to the user to improve wearing comfort and to minimize the potential for development of undesirable skin conditions due to the prolonged exposure to moisture absorbed within the article. Accordingly, it is generally desirable to promote rapid fluid transfer in a direction away from the wearer and into a retentive structure, while resisting fluid transfer in the reverse direction.

One viable prior art solution to the aforementioned problem has been to utilize a covering or topsheet on the exposed, wearer-contacting layer which comprises a web of formed, apertured thermoplastic film. Commonly assigned U.S. Patent No. 4,342,314, issued to Radel et al. on August 3, 1982, the disclosure of which is hereby incorporated herein by reference, discloses a representative formed film of this variety. Such webs utilize capillary fluid transport to conduct fluid away from one surface (wearer-contacting) into and through the web via three-dimensional capillaries formed into the material, and then into the underlying absorbent structure. In order to address consumer concerns with regard to plastic-like appearance and feel, webs of this variety have been developed which include an interconnected structure of fiber-like appearance in the interest of generating a more cloth-like, aesthetically-pleasing appearance. In addition, apertured, formed thermoplastic film webs have been developed which further include microscopic surface texturing (microtexture) and/or microscopic apertures (microapertures) to further enhance the visual and tactile impression of such webs. Representative film webs of this variety are disclosed in commonly assigned US Patents 4,463,045, issued to Ahr et al. on July 31, 1984, and 4,629,643, issued December 16, 1986 to Curro et al., the disclosures of which are hereby incorporated herein by reference.

Another viable prior art solution has been to utilize a fibrous material as a covering or topsheet on such articles, alone or as an overlay or laminate over other materials. A representative topsheet structure of this variety is disclosed in Statutory Invention Registration H1670 published in the name of Aziz et al. on July 1, 1997, the disclosure of which is hereby incorporated herein by reference. Such fibrous materials may take the form of a woven or nonwoven web of a suitable fiber variety, and may or may not include discretely formed apertures in addition to the inherent porosity of the web itself. Webs of this variety also exhibit capillary fluid transport characteristics via the three-dimensional capillaries formed by inter-fiber spaces, likewise conducting fluid away from the wearer-contacting surface and into the underlying absorbent structure. Such webs exhibit an aesthetically-pleasing, cloth-like surface appearance and tactile impression due to the fibrous nature of the surface.

Another prior art solution to increase the rate of fluid transfer away from the wearer has been the addition of a surfactant, or wetting agent, to the web to increase wettability. The surfactant may either be incorporated into the web itself (resin incorporated surfactant (RIS)) in accordance with U.S. Patent No. 4,535,020, issued in the name of Thomas et al. on August 13, 1985 and the aforementioned Statutory Invention Registration H1670, or, alternatively, may be applied to the surface of the web by spraying, printing, or other suitable methods such as disclosed in U.S. Patent No. 4,950,264, issued to Osborn on August 21, 1990.

The art has also used depositions of a low surface energy material on a surface of an apertured web having an underlying polymeric structure with a higher surface energy to provide a surface energy gradient. As described herein, such a surface energy gradient facilitates movement of moisture from the top surface of the web to the back surface. An example of this method is disclosed in commonly assigned Serial No. 08/826,508 filed in the name of Ouelette et al. on April 11, 1997. An exemplary coating material is a hydrophobic silicone resin. While such low surface energy depositions provide desirable fluid handling properties, they are relatively expensive and require additional process steps.

While capillary webs of the foregoing varieties are effective in transporting fluid, their effectiveness is limited in that such capillary structures can only move fluid once it reaches the capillary interior. Fluid which wets and remains on wearer contacting surfaces contributes to a "wet" tactile feeling or impression, and to the extent that such fluid may be colored or opaque also contributes to a "stained" visual impression.

Another problem associated with prior art capillary webs is their fluid retention when subjected to pressures associated with their use. The topsheet webs of the prior art do not prevent

some of the fluid that has been transported away from the surface from passing back through the topsheet onto the wearer contact surface. As with fluid that remains on the wearer contact surface, fluid that passes back through the topsheet onto the wearer contact surface also contributes to a "wet" tactile feeling or impression, and a "stained" visual impression.

Additionally, the RIS approach has several disadvantages. First, the surfactant is migratable, meaning that it may diffuse away from the topsheet, thus reducing topsheet wettability and possibly contaminating other components of the absorbent article. Second, surfactant may be lost during the forming process, thus potentially leading to foaming of the water system used for forming. Third, surfactant on the surface of the topsheet is normally depleted during use due to surfactant wash-off and migration. Finally, surfactants commonly used in absorbent articles are often complex molecules and mixtures of complex molecules. This results in surfactant having varying migration and therefore the topsheet experiences a surfactant composition that changes over time. The above disadvantages can result in a web having wettability with little durability.

Accordingly, it would be desirable to provide a web with enhanced effectiveness in transporting fluid away from one surface which is initially contacted by a fluid. It would also be desirable to provide a web that better prevents absorbed fluid from passing back out of the absorbent core of the article and onto the wearer contacting surface. Additionally, it would be desirable to provide a topsheet having durable wettability, i.e., permanent hydrophilicity, while avoiding the complexity of the RIS process. It would also be desirable to achieve a surface energy gradient while avoiding the use of hydrophobic coatings or surfactant treatments.

More particularly, it would be desirable to retain pleasing visual and tactile properties of webs having fibrous or otherwise textured surfaces while promoting more rapid and more complete fluid transport away from the wearer-contacting surface and into the interior of an associated absorbent article.

SUMMARY OF THE INVENTION

The present invention pertains to a microapertured, fluid permeable web provided with a texture and suitable as a topsheet on a disposable absorbent article. In one embodiment of the present invention, the fluid permeable web comprises a polymeric formed film ply having at least two layers, each of the layers having opposed first and second exterior surfaces. The polymeric formed film ply is provided with microapertures placing the first exterior surface and the second exterior surface in fluid communication with one another and the exterior surfaces are comprised of materials that provide a surface energy gradient between the surfaces.

A further embodiment of the present invention is where at least one of the exterior surfaces is comprised of a hydrophilic block copolymer and the hydrophilic block copolymer comprises blocks of a polyether and another polymer selected from the group consisting of a polyester, a polyamide, and a polyurethane.

Another embodiment of the present invention is a fluid permeable web comprising a polymeric formed film ply having a monolayer comprised of a hydrophobic composition as defined herein.

A further embodiment of the present invention is a fluid permeable film web comprising a polymeric formed film ply having a monolayer comprised of a hydrophilic composition comprising a block copolymer of a polyether and another polymer.

A still further embodiment of the present invention is a fluid permeable web comprising a polymeric formed film ply having a first layer and a second layer, both layers having a first surface and a second surface, where one of the layers is a hydrophobic composition as defined herein and the other layer comprises a hydrophilic composition comprising a block copolymer of a polyether and another polymer, and at least one intermediate layer between the first and second layers.

A still further embodiment of the present invention is a fluid permeable web comprising a polymeric formed film ply having a first layer and a second layer, both layers having a first surface and a second surface, where one of the layers is a hydrophobic composition as defined herein and the other layer comprises a hydrophilic composition comprising a block copolymer of a polyether and another polymer, and a hydrophilic, fluid permeable transport ply having a first surface and a second surface. The transport ply has a plurality of fluid passageways that places the first and second surfaces in fluid communication with one another. The second surface of the second layer of the polymeric formed film ply is joined to the first surface of the transport ply.

A still further embodiment of the present invention is a fluid permeable web comprising a polymeric formed film ply having a first layer and a second layer, both layers having a first surface and a second surface, where one of the layers is a hydrophobic composition as defined herein and the other layer comprises a hydrophilic composition comprising a block copolymer of a polyether and another polymer, a hydrophilic, fluid permeable transport ply having a first surface and a second surface, and at least one intermediate layer between the formed film ply and the transport ply.

Still further embodiments of the present invention are providing at least one of the surfaces of the fluid permeable webs delineated above with a treatment and/or a texture.

Still further embodiments of the present invention may include any number of layers. In addition, the intermediate layer or layers may comprise any polymeric material. Any number of intermediate layers may be utilized in forming the polymeric formed film plies of the present invention. Depending on the preferred structure, the body contacting surfaces may be comprised of either hydrophilic block copolymers or hydrophobic polymers, or a combination thereof, as described above.

The polymeric formed film of the present invention provides many advantages. The use of a block copolymer of a polyether and another polymer as the hydrophilic surface renders the film permanently hydrophilic. The permanent hydrophilicity gives the film durable wettability without the need for surfactant treatment or the addition of silicone, thus avoiding the problems and complexities often found in the prior art. An additional benefit realized by microaperturing the web and further enhanced by treating the web body contacting surface is that the web is softer and silkier to the touch.

The fluid permeable web, comprising a polymeric film in accordance with the present invention, may also be provided with a surface energy gradient, defined herein, which assists in the effective transport of fluid away from the first or wearer-contacting surface. The web substantially retains its visual, tactile, and physical properties of the substrate polymeric film material while achieving the desired fluid handling properties.

The present invention also pertains to absorbent articles which preferably include a topsheet formed from the fluid permeable web of the present invention, a backsheet secured to the topsheet, and an absorbent core positioned between the topsheet and the backsheet.

BRIEF DESCRIPTION OF THE DRAWINGS

While the specification concludes with claims particularly pointing out and distinctly claiming the present invention, it is believed that the present invention will be better understood from the following description in conjunction with the accompanying drawings, in which like reference numbers identify like elements, and wherein:

Figure 1 is a cross-sectional view showing one embodiment of polymeric film of the present invention;

Figure 2 is an enlarged cross-sectional view showing a textured polymeric formed film ply having an arrangement of microapertures according to the present invention;

Figure 3 is a cross-sectional view showing one embodiment of the polymeric film of the present invention;

Figure 4 is a cross-sectional view showing one embodiment of the polymeric film of the present invention;

Figure 5 is a cross-sectional view showing one embodiment of the polymeric film of the present invention;

Figure 6 is a cross-sectional view showing one embodiment of the polymeric film of the present invention;

Figure 7 is an enlarged cross-sectional view of a droplet of liquid on a solid surface having two different surface energies, thus exhibiting two different water contact angles A(a) and A(b);

Figure 8 is a top plan view of a sanitary napkin with portions of the sanitary napkin cut away to more clearly show the construction of the sanitary napkin;

Figure 9 is a cross-sectional view of the sanitary napkin of Figure 8 taken along section line 8-8; and

Figure 10 is an enlarged, partially segmented, perspective illustration of a representative absorbent article in the form of a diaper made in accordance with the present invention.

DETAILED DESCRIPTION OF THE PRESENT INVENTION

Definitions

As used herein, the term "hydrophilic" is used to refer to surfaces that are wettable by aqueous fluids (e.g., aqueous body fluids) deposited thereon. Hydrophilicity and wettability are typically defined in terms of water contact angle and the surface tension of the fluids and solid surfaces involved. This is discussed in detail in the American Chemical Society publication entitled Contact Angle, Wettability and Adhesion, edited by Robert F. Gould (Copyright 1964), which is hereby incorporated herein by reference. A surface is said to be wetted by a fluid (hydrophilic) when the fluid tends to spread spontaneously across the surface as opposed to forming discrete droplets. Conversely, a surface is considered to be "hydrophobic" if the fluid tends to form discrete droplets and does not spread spontaneously across the surface. As used

herein, a "hydrophilic film or layer" generally has a water contact angle less than about 50 degrees. As used herein, a "hydrophobic film or layer" generally has a water contact angle greater than about 50 degrees.

The water contact angle depends on surface inhomogeneities (e.g., chemical and physical properties, such as roughness), contamination, chemical/physical treatment of the solid surface, or composition of the solid surface, as well as contamination of the water. The surface energy of the solid also influences the water contact angle. As the surface energy of the solid decreases, the water contact angle increases. As the surface energy of the solid increases, the water contact angle decreases.

The energy required to separate a liquid from a solid surface (e.g., a film or fiber) is expressed by equation (1):

$$(1) \quad W = G (1 + \cos A)$$

where:

W is the work of adhesion measured in erg/cm²

G is the surface tension of the liquid measured in dyne/cm, and

A is the liquid-solid water contact angle measured in degrees.

With a given liquid, the work of adhesion increases with the cosine of the liquid-solid water contact angle (reaching a maximum where the water contact angle A is zero).

Work of adhesion is one useful tool in understanding and quantifying the surface energy characteristics of a given surface. Another useful method which could be utilized to characterize the surface energy characteristics of a given surface is the parameter labeled "critical surface tension", as discussed in H. W. Fox, E. F. Hare, and W. A. Zisman, J. Colloid Sci. 8, 194 (1953), and in Zisman, W. A., Advan. Chem. Series No. 43, Chapter 1, American Chemical Society (1964), both of which are hereby incorporated herein by reference.

Illustrated below in Table 1 is the inverse relationship between water contact angle and work of adhesion for a particular fluid (e.g., water), whose surface tension is 75 dynes/cm.

TABLE 1

<u>A (degrees)</u>	<u>cos A</u>	<u>1+cos A</u>	<u>W (erg/cm²)</u>
0	1	2	150
30	0.87	1.87	140
60	0.5	1.50	113
90	0	1.00	75
120	-0.5	0.5	38
150	-0.87	0.13	10
180	-1	0	0

As shown in Table 1, as the work of adhesion decreases (i.e. the surface exhibits a lower critical surface tension), the contact angle for water on the surface increases, and hence the fluid tends to "bead up" and have a smaller surface area of contact. The reverse is likewise true with contact angle decreasing with increasing work of adhesion.

As used herein, the term "gradient" when applied to differences in surface energy or work of adhesion is intended to describe a change in surface energy or work of adhesion occurring over a measurable distance. The term "discontinuity" is intended to refer to a type of "gradient" or transition, wherein the change in surface energy occurs over an essentially zero distance. Accordingly, as used herein all "discontinuities" fall within the definition of "gradient".

Also, as used herein the terms "capillary" and "capillarity" are used to refer to passageways, apertures, pores, or spaces within a structure which are capable of fluid transport in accordance with the principles of capillarity generally represented by the Laplace equation (2):

$$(2) \quad \Delta p = 2G (\cos A) / R$$

where:

p is the capillary pressure;

R is the internal radius of the capillary (capillary radius); and

G and A are as defined above.

As noted in Penetration of Fabrics by Emery I. Valko, found in Chapter III of Chem. Aftertreat. Text. (1971), pp. 83-113, which is hereby incorporated herein by reference, for A = 90°, the cosine of A is zero and there is no capillary pressure. For A > 90°, the cosine of A is negative and the capillary pressure opposes the spontaneous entry of fluid into the capillary. For

$A < 90^\circ$ the cosine of A is positive and the capillary pressure permits the entry of fluid into the capillary. Also, R must be sufficiently small for p to have a meaningful value, since as R increases (larger aperture/capillary structure) the capillary pressure decreases.

As utilized herein, the term "incompatible" represents the lack of miscibility between two materials such that each phase substantially retains its original properties. Example properties include glass transition temperature or melting point. Another characterization of incompatible materials is that the strength of the interface is significantly weaker than the strength of the weakest individual phase (material). Thus, the work of adhesion between the two materials is much lower than the lowest cohesive energy of either material, and the risk of delamination is high.

The term "topsheet" generally refers to the cover layer, in an absorbent article such as a diaper or catamenial pad, that faces the wearer of the absorbent article. The term "wearer-contacting layer or surface" as used herein refers to the layer or surface of a topsheet or other absorbent article component that is nearest the wearer of the article. The term "garment-facing layer or surface" refers to the layer or surface of a topsheet or other absorbent article component that faces away from the wearer when the component is used in an absorbent article.

The term "Z-dimension" refers to the dimension orthogonal to the length and width of the layer, structure or article. The Z-dimension usually corresponds to the thickness of the layer, structure or article.

The terms "fiber-like" or "cloth-like," as utilized herein to describe the appearance of plastic polymeric films, refers generally to any fine scale pattern of embossments or apertures, random or non-random, reticulated or non-reticulated, which can provide an overall appearance and impression of a woven or nonwoven fibrous polymeric structure when viewed by the human eye at a distance of 12 inches (30 cm). When describing the elements used to form the polymeric film, the term "fiber-like" is utilized herein to describe the appearance or shape of the elements.

The term "texture" refers to various methods for providing a topsheet with a three-dimensional caliper. Such methods include but are not limited to embossing, creping, structural elastic like film (SELF-ing), and ring-rolling. Specific references providing descriptions of individual texturing methods are provided below.

The term "treatment" refers to various methods for creating fibrillated substrates to enhance softness of a topsheet material. Such methods include but are not limited to brushing, flocking,

delamination of viscous melts from porous surfaces, and printed hair. Specific references providing descriptions of individual treatment methods are provided below.

As utilized herein, the term "fluid passageway" is intended to encompass enclosed or at least partially enclosed structures or channels which may communicate fluids. The term fluid passageway is thus intended to encompass the terms "aperture", "channel", "capillary", as well as other similar terms. The passageways inherent in fluid permeable materials are another example. Many other examples of fluid passageways exist in the art and may be used in the present invention.

The term "monolayer" refers to a ply that is comprised of a single layer of material.

The term "transport ply" refers to a ply having body facing and garment facing surfaces that are joined to adjacent surfaces. Whereby, the "transport ply" serves to promote fluid communication between the adjacent surfaces.

The term "web" as used herein refers to a structure comprised of one or more ply.

The term "layer" as used herein refers to an individual layer of material that is joined to at least one other layer of material to form a ply.

The term "ply" as used herein refers to a structure that is comprised of one or more layers of material.

The term "surface" as used herein refers to a top or first side of a layer and/or a bottom or second side of a layer.

In general, as utilized herein the term "macroscopic" is used to refer to structural features or elements which are readily visible to a normal human eye when the perpendicular distance between the viewer's eye and the plane of the web is about 12 inches. Conversely, the term "microscopic" is utilized to refer to structural features or elements which are not readily visible to a normal human eye when the perpendicular distance between the viewer's eye and the plane of the web is about 12 inches (30 cm). Accordingly, the term "microaperture" refers to an aperture that is microscopic in size.

As used herein, the term "absorbent article" refers to devices which absorb and contain body exudates, and, more specifically, refers to devices which are placed against or in proximity to the body of the wearer to absorb and contain the various exudates discharged from the body. The term "disposable" is used herein to describe absorbent articles which are not intended to be laundered or otherwise restored or reused as an absorbent article (i.e., they are intended to be discarded after a

single use, and, preferably, to be recycled, composted or otherwise disposed of in an environmentally compatible manner). A "unitary" absorbent article refers to absorbent articles which are formed of separate parts united together to form a coordinated entity so that they do not require separate manipulative parts like a separate holder and pad.

The Polymeric Formed Film Ply of the Present Invention

The polymeric formed film ply of the present invention may comprise one of many different configurations depending on the film properties desired. The properties of the formed film ply of the present invention may be manipulated by varying, for example, the number of layers, the chemistry of the layers, i.e., hydrophobic or hydrophilic, and the types of polymers used to form the polymeric layers.

Film structures having two or more layers are preferred for purposes of the present invention for several reasons including: 1) such structures provide hydrophilicity at minimal usage of the relatively expensive hydrophilic block copolymers described herein; 2) such structures can compensate for nonoptimal film forming and converting properties of a hydrophilic layer; and 3) such structures can compensate for nonoptimal mechanical properties of a hydrophilic layer. While multi-layered structures are preferred, monolayer film structures are also within the scope of the present invention.

One embodiment of the polymeric formed film ply of the present invention is a microapertured, textured, dual layer film comprising a first layer and a second layer. In accordance with the present invention, one of the first and second layers is hydrophobic while the other is a hydrophilic composition comprising a block copolymer of a polyether and another polymer selected from the group consisting of a polyester, a polyamide, and a polyurethane.

Figure 1 is a cross-sectional view of one dual layer film embodiment of the polymeric formed film ply of the present invention, generally depicted as 100. The film 100 is a dual layer film comprising first layer 110 and second layer 120. In accordance with the present invention, the exterior surface materials are selected such that a surface energy gradient is provided between the two surfaces. In one preferred embodiment, one of the first and second layers may be hydrophilic while the other is hydrophobic. Alternatively, the first and second layers may both be either hydrophilic or hydrophobic. This alternative structure can have particularly useful properties because, with proper choice of layer composition, hydrophilic layers having different degrees of hydrophilicity can be produced. Figure 2 is an enlarged cross-sectional view showing a textured polymeric formed film ply having an arrangement of microapertures and according to

the present invention. Texture is defined further below. An alternative embodiment may be developed by providing the embodiment defined as Figure 1 with a treatment. Treatments are defined further below.

Figure 3 is a cross-sectional view of another embodiment of the polymeric formed film ply of the present invention, generally depicted as 300. This embodiment is a microapertured, monolayer polymeric formed film ply comprised of either a hydrophobic composition or a hydrophilic composition comprising a block copolymer of a polyether and another polymer selected from the group consisting of a polyester, a polyamide, and a polyurethane.

Another embodiment of the polymeric formed film ply of the present invention is a multi-layer film comprising a first layer, a second layer, and at least one intermediate layer between the first and second layers. Each of the first and second layers may be either a hydrophobic layer or a hydrophilic layer comprising a block copolymer of a polyether and another polymer. If the multi-layer formed film ply includes two adjacent layers that comprise incompatible materials, then the intermediate layer between them preferably is a tie layer, tie layers being defined below.

Figure 4 is a cross-sectional view of one embodiment of a multi-layer formed film ply of the present invention, generally depicted as 400. This embodiment is a three layer formed film ply comprising a first layer 410, a second layer 430, and an intermediate layer, 420. Preferably, one of the first and second layers is a hydrophobic layer while the other layer is a hydrophilic layer comprising a block copolymer of a polyether and another polymer. In such a case, the intermediate layer 420 is preferably a tie layer that facilitates the bonding of the at least partially incompatible hydrophobic and hydrophilic layers. Such tie layers are described in further detail below.

The first and second layers may also both be hydrophilic or both hydrophobic. If the first and second layers comprise incompatible materials, then the intermediate layer preferably is a tie layer. An alternative embodiment may be developed by providing the embodiment defined as Figure 4 with a treatment. Treatments are defined further below.

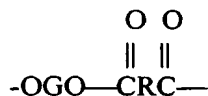
The polymeric formed film ply of the present invention may include any number of layers as long as there is a tie layer between any adjacent layers that comprise incompatible materials. In addition, the intermediate layer or layers may comprise any polymeric material as long as there is a tie layer between any adjacent incompatible layers. Any number of intermediate layers may be utilized in forming the polymeric formed film plies of the present invention. Depending

on the preferred structure, the outer layers may be either hydrophilic block copolymers or hydrophobic polymers, or a combination thereof, as described above.

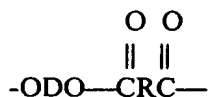
As described herein below, another aspect of the present invention is a topsheet comprising the polymeric formed film ply of the present invention. The material selected for the polymeric formed film ply of the present invention, and therefore for the topsheet formed therefrom, is preferably machinable and capable of being formed into a sheet. Since the topsheet is to be used in consumer products which contact the human body, the material utilized in the polymeric formed film ply used to form the topsheet is safe and preferably soft for epidermal or other human contact.

Generally, the hydrophilic layer of the present invention comprises a polymer selected from a class of compounds generally described as block copolymers. The blocks are comprised of hydrophobic segments and hydrophilic segments. Generally, the hydrophobic blocks are termed "hard" because the glass transition temperature is typically above room temperature. Contrarily, the hydrophilic blocks are termed "soft" because the glass transition temperature is typically below room temperature. Suitable hard blocks include 1) polyesters such as poly(ethylene terephthalate) and poly(butylene terephthalate); 2) polyamides such as nylon 6 and nylon 66; 3) polyurethanes. Suitable soft blocks include polyethers such as poly(butylene glycol), poly(ethylene glycol), poly(ethylene glycol - co - propylene glycol). Preferably, the hydrophilic layer comprises a segmented block copolymer of the above-identified hard and soft blocks.

Exemplary hydrophilic copolyetheresters comprise a hydrophilic elastomer or a mixture of two or more hydrophilic copolyetherester elastomers having a multiplicity of recurring long-chain ester units and short chain ester units joined through ester linkages, the long-chain ester units being represented by the formula



and the short-chain ester units being represented by the formula:

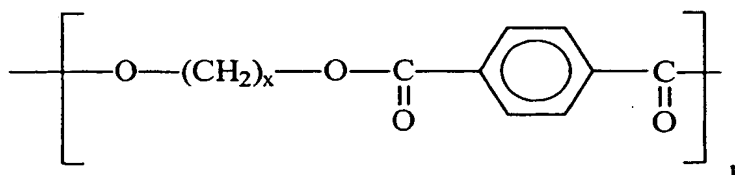


where G is a divalent radical remaining after the removal of terminal hydroxyl groups from a poly(alkylene oxide) glycol having an average molecular weight of about 400-4000; R is a

divalent radical remaining after removal of carboxyl groups from a dicarboxylic acid having a molecular weight less than 300; and D is a divalent radical remaining after removal of hydroxyl groups from a diol having a molecular weight less than about 250.

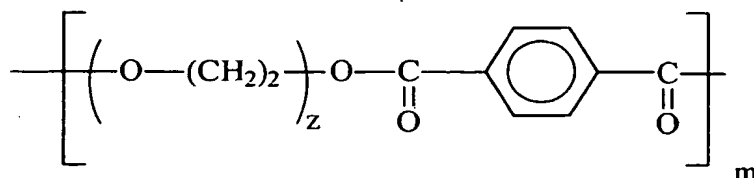
Representative long-chain glycols used to prepare the copolyetheresters that form the hydrophilic material include poly(ethylene oxide) glycol, poly(1,2 and 1,3-propylene oxide) glycol, poly(tetramethylene oxide) glycol, ethylene oxide capped polypropylene oxide glycol, mixtures of poly(ethylene oxide) glycol with other glycols such as ethylene oxide capped poly(propylene oxide) glycols and/or poly(tetramethylene oxide) glycol and their random or block copolymers provided the resulting copolyetherester has an amount of ethylene oxide groups of at least about 25 weight percent. Preferably, the amount of ethylene oxide groups incorporated in the copolyetherester or mixture of two or more copolyetheresters by the poly(alkylene oxide) glycol is from about 25-75 and, more preferably, from about 40 to 68 weight percent based on the total weight of the copolyetherester or mixture of two or more copolyetheresters. The ethylene oxide groups in the copolyetherester that are counted to determine the amount in the polymer are those derived from the poly(alkylene oxide) glycol and not ethylene oxide groups that can be introduced into the copolyetherester by means of low molecular weight diol.

Examples of such compounds can be found in U.S. Patent No. 4,725,481 issued to Ostapchenko on February, 16, 1988, herein incorporated by reference. Such compounds are block copolymers of a polyester and a polyether and are sold by DuPont of Wilmington, DE under the tradename Hytrel®. A preferred polyetherester of this type of compound is a copolymer of a polyalkylene terephthalate (a polyester derivative polymer) having the following structure:



in which x equals 2 or 4,

and a long chain polyether glycol having the following structure:



in which z is between about 8 and about 80. Hytrel® is available in a variety of formulations of varying hydrophilicity. Preferred for the present invention are formulations sold under the names Hytrel® HTR 8171 or Hytrel® HTR 8206. Particularly preferred is a blend of equal parts of Hytrel® HTR 8171 or Hytrel® HTR 8206.

Another example of a suitable block copolymer for use as the hydrophilic material is a group of compounds generally comprising block copolymers of a polyether and a polyamide. Each of the polyetheramide copolymers have polyether segments and polyamide segments. Exemplary polyethers are polyetherdiols including polyethylene glycol, polypropylene glycol, polytetramethylene glycol, mixtures of at least two of such polyetherdiols, and their copolymers. Exemplary copolyetherdiols include random and/or block copolymers of ethylene glycol and/or of 1,2 or 1,3 propylene glycol. The molecular weight of these polyethers ranges from about 250 to 10,000 and preferably from 400 to 4,000. The polyetheramide preferably contains between 40 wt. % and 80 wt. % polyether and more preferably between 50 wt. % and 70 wt. %. These segments may be prepared by reacting a dicarboxylic polyamide with a polyoxyalkylene glycol at sufficiently elevated temperature and under sufficiently high vacuum in the presence of a suitable catalyst. Polymers of this type are discussed more fully in US Patents 4,331,786, 4,839,441, 4,839,441, 4,273,898, 5,166,309, and 5,213,891. The disclosure of each being incorporated herein by reference. Such materials are commercially available from Elf Atochem North America, Inc. of Philadelphia, PA under the tradename Pebax®.

Still another example of a suitable block copolymer for use as the hydrophilic material is a group of compounds generally comprising block copolymers of a polyether and a polyurethane as are available from BF Goodrich High Performance Materials of Cleveland, OH under the tradename Estane®.

While the chemistry of the block copolymer of a polyether and another polymer may vary, the primary measure of polymer acceptability is the water contact angle. The hydrophilic block copolymer layer of the polymeric formed film ply of the present invention preferably has a

water contact angle less than about 50 degrees, more preferably less than about 40 degrees, and most preferably less than about 30 degrees.

It is preferred that the hydrophobic layer comprise a soft resin with a modulus less than 1,000 MPa, preferably less than 700 MPa, be used. Suitable test methods for measuring the modulus of a polymer include ASTM D882 or D632. Many resins may meet this criterion by using copolymers, tacticity in homopolymers, blends with softer materials, or additives such as plasticizers. The hydrophobic layer is typically comprised of a polyolefin resin such as polyethylene. A preferred polyethylene is available from Tredegar Film Products of Richmond, VA under the code X-8318. Other polyolefin resins such as polypropylene, ethylene vinyl acetate, and ethylene methyl acrylate may be used. Other thermoplastic resins such as polyester, polyamides, and polyvinyl chloride may be used if: (1) the water contact angle of the resin falls within the range of acceptable values set forth herein, (2) suitable tie layer materials exist, and (3) the resins are amenable to thermoplastic processing to form the multi-layer films of the present invention. For example, an aliphatic polyester can be used as the hydrophobic layer. Films from these materials can easily be fabricated into formed films. Such resins generally have the added benefit of not requiring a tie layer when used with hydrophilic resins such as the polyetherester resins described above. In certain embodiments, aliphatic polyesters are also biodegradable providing additional utility. Another example of a suitable polyester-type resin that is suitable for the hydrophobic layer of the present invention is a hydrophobic block copolymer of a polyester and a polyether to provide a water contact angle that is about 60° that is available from DuPont as Hytrel® HTR 5556.

The hydrophobic layer of the polymeric formed film ply of the present invention preferably has a water contact angle greater than about 50 degrees, more preferably greater than about 80 degrees.

If incompatible polymeric layers are to be adjacent in a multi-layer formed film ply structure, a tie layer is preferably positioned between them. The purpose of the tie layer is to provide a transition and adequate adhesion between incompatible materials. An adhesive or tie layer is typically used between layers of thermoplastic resins that exhibit delamination when stretched, distorted, or deformed. The delamination may be either microscopic separation or macroscopic separation. In either event, the performance of the film may be compromised. Consequently, a tie layer that exhibits adequate adhesion between the layers should be used.

A tie layer would generally be useful between incompatible materials such as when a copoly(ester-ether) is not adjacent to another copoly(ester-ether). For instance, when a polyolefin and a copoly(ester-ether) are the adjacent layers, a tie layer would generally be useful.

The tie layer is chosen according to the nature of the adjacent materials. It will have a backbone that is compatible with and is preferably identical to one material (e.g. nonpolar and hydrophobic layer) and a reactive group which is compatible or interacts with the second material (e.g. polar and hydrophilic layer).

Suitable backbones for the tie layer include polyethylene (low density - LDPE, linear low density - LLDPE, high density - HDPE, and very low density - VLDPE) and polypropylene.

The reactive group may be a grafting monomer that is grafted to this backbone, and is or contains at least one alpha- or beta- ethylenically unsaturated carboxylic acid or anhydrides, or a derivative thereof. Examples of such carboxylic acids and anhydrides, which maybe mono-, di-, or polycarboxylic acids, are acrylic acid, methacrylic acid, maleic acid, fumaric acid, itaconic acid, crotonic acid, itaconic anhydride, maleic anhydride, and substituted malic anhydride, e.g. dimethyl maleic anhydride. Examples of derivatives of the unsaturated acids are salts, amides, imides and esters e.g. mono- and disodium maleate, acrylamide, maleimide, and diethyl fumarate.

A particularly preferred tie layer is a low molecular weight polymer of ethylene with about 0.1 to about 30 weight percent of one or more unsaturated monomers which can be copolymerized with ethylene, e.g., maleic acid, fumaric acid, acrylic acid, methacrylic acid, vinyl acetate, acrylonitrile, methacrylonitrile, butadiene, carbon monoxide, etc. Preferred are acrylic esters, maleic anhydride, vinyl acetate, and methacrylic acid. Anhydrides are particularly preferred as grafting monomers with maleic anhydride being most preferred.

An exemplary class of materials suitable for use as a tie layer is a class of materials known as anhydride modified ethylene vinyl acetate sold by DuPont under the tradename Bynel®. A preferred anhydride modified ethylene vinyl acetate formulation is sold by DuPont under the tradename Bynel® 3860. Another material suitable for use as a tie layer is an anhydride modified ethylene methyl acrylate also sold by DuPont under the tradename Bynel®. A preferred anhydride modified ethylene methyl acrylate is sold by DuPont under the tradename Bynel® 2169. Maleic anhydride graft polyolefin polymers suitable for use as tie layers are also

available from Elf Atochem North America, Functional Polymers Division, of Philadelphia, PA as Orevac®.

Alternatively, a polymer suitable for use as a tie layer material can be incorporated into the composition of one or more of the layers of the polymeric formed film ply of the present invention. By such incorporation, the properties of the various layers are modified so as to improve their compatibility and reduce the risk of delamination.

Other intermediate layers besides tie layers may be used in the multi-layer formed film ply of the present invention. For example, a layer of a polyolefin resin could be used between two outer layers of a hydrophilic resin, such as those discussed above, to provide additional mechanical strength to the extruded web. Any number of intermediate layers may be used. Examples of suitable thermoplastic materials for use in forming intermediate layers include polyethylene resins such as low density polyethylene (LDPE), linear low density polyethylene (LLDPE), ethylene vinyl acetate (EVA), ethylene methyl acrylate (EMA), polypropylene; and poly(vinyl chloride). Preferred polymeric layers of this type have mechanical properties that are substantially equivalent to those described above for the hydrophobic layer.

The polymers used to form the polymeric formed film plies of the present invention may contain other ingredients such as fillers, pigments, and the like as is well known in the art. The only limitation on the use of such other ingredients is that the water contact angles of the polymeric layers fall within the ranges set forth above for the hydrophilic and hydrophobic layers respectively.

For multi-layer structures, the weight of an individual hydrophilic layer is suitably less than about 30% of the weight of the entire film. Preferably, the weight of the hydrophilic layer is suitably less than about 15% of the weight of the entire film. Most preferably, the hydrophilic layer is between about 5% and 10% of the weight of the entire film. If one intermediate layer is used, the weight of the intermediate layer is preferably less than 30% of the weight of the entire film.

It is preferred that the thickness of the entire web is less than 0.051 mm (2 mil). Preferably the thickness is between about 0.012 mm (0.5 mil) and about 0.051 mm (2.0 mil). More preferably, the thickness is between about 0.012 mm (0.5 mil) and about 0.038 mm (1.5 mil). A particularly preferred film has a thickness of about 0.025 mm (1 mil).

The Fluid Pervious Web of the Present Invention

Another aspect of the present invention is a fluid pervious web suitable for use as a topsheet in an absorbent article. As is described below, the fluid pervious web of the present invention contains a plurality of microapertures. Microapertures give the fluid pervious web a more consumer-preferred fiber-like or cloth-like appearance and softer, silkier feel than webs that are embossed or needle punched. In the present invention, the microapertures in conjunction with a provided surface energy gradient serve to transport fluids away from the wearer contacting surface of the topsheet towards the absorbent core. Although the fluid pervious web of the present invention is described herein as a topsheet for use in an absorbent article, one having ordinary skill in the art would recognize that the fluid pervious web of the present invention would have other uses, such as bandages, agricultural coverings, and similar uses where it is desirable to manage fluid flow through a layer.

The microapertures are preferably formed by applying a high pressure fluid jet comprised of water or the like against one surface of the flat film ply, preferably while applying a vacuum adjacent the opposite surface of the flat film ply. In general, the flat film ply is supported on one layer of a forming structure having opposed layers. The forming structure is provided with a multiplicity of apertures therethrough which place the opposed layers in fluid communication with one another. While the forming structure may be stationary or moving, a preferred embodiment uses the forming structure as part of a continuous process where the flat film ply has a direction of travel and the forming structure carries flat film ply in the direction of travel while supporting the film. The fluid jet and, preferably, the vacuum cooperate to provide a fluid pressure differential across the thickness of the film causing the film to be urged into conformity with the forming structure and to rupture in areas that coincide with the apertures in the forming structure.

Such methods of aperturing are known as "hydroformation" and are described in greater detail in commonly assigned US Patents 4,609,518 issued to Curro et al. on Sept. 2, 1986; 4,629,643 issued to Curro et al. on Dec. 16, 1986; 4,637,819 issued to Ouellette et al. on Jan. 20, 1987; 4,681,793 issued to Linman et al. on July 21, 1987; 4,695,422 issued to Curro et al. on Sept. 22, 1987; 4,778,644 issued to Curro et al. on Oct. 18, 1988; 4,839,216 issued to Curro et al. on June 13, 1989; and 4,846,821 issued to Lyons et al. on July 11, 1989, the disclosures of each of said patents being incorporated herein by reference.

The apertured web of the present invention may also be formed by methods such as vacuum formation and using mechanical methods such as punching. Vacuum formation is disclosed in U.S. Patent No. 4,463,045, issued to Ahr et al. on July 31, 1984, the disclosure of which is hereby incorporated herein by reference. Examples of mechanical methods are disclosed in US Patents 4,798,604, 4,780,352, and 3,566,726 the disclosures of which are incorporated herein by reference.

Figure 2 depicts an enlarged cross-sectional view of a web structure 200 according to the present invention in which microapertures 210 have been formed. The size of the microapertures may also be varied, however, it is preferred that the microapertures are formed using a 100 mesh screen as described in the examples below.

The performance properties of the topsheet of the present invention may be manipulated depending on the orientation of the hydrophilic block copolymer layer and the hydrophobic layer in the polymeric formed film ply from which the topsheet is formed. As described above, the polymeric formed film ply of the present invention may comprise any number of layers. The topsheet may be formed so that the wearer-contacting layer is a hydrophobic layer and the garment-facing layer is hydrophilic (known as "phobic/philic"), or so that the wearer-contacting layer is hydrophilic and the garment facing layer is hydrophobic (known as "philic/phobic"). In addition, by varying both the orientation of the hydrophilic and hydrophobic layers, many different topsheet structures, with different advantageous properties, can be formed according to the present invention.

The preferred topsheet orientation, shown in Figures 1 and 2, is one in which the wearer-contacting layer or first layer 110 is hydrophobic, the opposed garment-facing layer or second layer 120 is hydrophilic. In Figure 2, the inside layers 230 of the microapertures are predominately hydrophilic layers and the land areas 220 between the microapertures on the wearer-contacting layer 110 are hydrophobic. As described below, this arrangement creates a surface energy gradient between the lands 220 and the interior of the microapertures. This gradient helps move a droplet of liquid from the lands into the microapertures 210 and thus away from the wearer-contacting layer 110 and toward the absorbent core of the absorbent article. Of course, other combinations of layers are possible and such combinations are part of the present invention.

Whenever the wearer-contacting layer and the garment-facing layer of the topsheet of the present invention comprise materials having different surface energy properties (eg., one of the

layers is hydrophobic and the other is hydrophilic), a surface energy gradient is created. Surface energy gradients have been found to be useful in promoting fluid transport. Figure 7 illustrates a droplet of fluid 700 which is located on a solid layer having two regions 710 and 720 having differing surface energies (indicated by the different cross-hatching for illustrative purposes). In the situation illustrated in Figure 7, region 710 exhibits a comparatively lower surface energy than region 720, and hence a reduced wettability for the fluid of the droplet than region 720. Accordingly, the droplet 700 produces a water contact angle $A(b)$ at the edge of the droplet contacting region 710 which is greater than the water contact angle $A(a)$ produced at the edge of the droplet contacting region 720. It should be noted that although for graphic clarity the points "a" and "b" lie in a plane, the distance "dx" between points "a" and "b" need not be linear, instead representing the extent of droplet/layer contact regardless of the shape of the layer. Droplet 700 thus experiences a surface energy imbalance and hence an external force due to the differences in the relative layer energies (i.e., a surface energy gradient) between regions 710 and 720, which can be represented by the equation (3):

$$(3) \quad dF = G [\cos A(a) - \cos A(b)] dx$$

where:

dF is the net force on the fluid droplet,

dx is the distance between the reference locations "a" and "b",

G is as defined previously, and

$A(a)$, and $A(b)$ are the water contact angles A at locations "a" and "b", respectively.

Solving equation (1) for $\cos A(a)$ and $\cos A(b)$ and substituting into equation (3) yields equation (4):

$$(4) \quad dF = G [(W(a)/G - 1) - (W(b)/G - 1)] dx$$

Equation (4) can be simplified to equation (5):

$$(5) \quad dF = (W(a) - W(b)) dx$$

The importance of the differential in surface energy between the two layers is clearly depicted in equation (5), as is the directly proportional effect that changes in the magnitude of the differential in work of adhesion would have on the magnitude of the force.

More detailed discussions of the physical nature of surface energy effects and capillarity may be found in Textile Science and Technology, Volume 7, Absorbency, edited by Portnoy K.

Chatterjee (1985), and Capillarity, Theory and Practice, Ind. Eng. Chem. 61,10 (1969) by A. M. Schwartz, which are hereby incorporated herein by reference.

Accordingly, the force experienced by a droplet will tend to cause movement in the direction of the higher surface energy region. For simplicity and graphic clarity, the surface energy gradient is provided by a single, sharp discontinuity or boundary between well-defined regions of constant but differing surface energy as shown in Figure 7. Surface energy gradients may also exist as a continuous gradient or a step-wise gradient, with the force exerted on any particular droplet (or portions of such droplet) being determined by the surface energy at each particular area of droplet contact.

By having a formed film ply with a surface energy gradient formed by structures creating a relatively low surface energy adjacent the portion of the topsheet film which will be placed adjacent to and in contact with the wearer's skin, and a relatively higher surface energy portion located away from contact with the wearer's skin, the topsheet will be capable of moving a drop of liquid from the portion of the topsheet exhibiting the relatively lower surface energy to the portion of the topsheet exhibiting the relatively higher surface energy. The motion of the drop of liquid is induced by the surface forces which also cause a water contact angle differential between the lower surface energy portion and the higher surface energy portion. It is believed that this resulting surface energy gradient, which enhances the fluid handling properties of the topsheet of the present invention, makes the topsheet well suited for use as a topsheet on an absorbent article.

In addition to the enhanced fluid handling properties, by designing topsheet so that its relatively lower surface energy portion can be placed in contact with the wearer's skin, the adhesion between the skin and the topsheet is reduced by decreasing the capillary force generated by occlusive body fluids located between the first layer of the topsheet and the wearer's skin. By providing a structure with reduced adhesion between the wearer's skin and the topsheet, the sensation or impression of stickiness associated with adhesion to a plastic topsheet is also reduced.

The potential for rewet is also reduced by having a topsheet with a surface energy gradient according to the aforementioned description. As use forces tend to force the collected fluid to rewet or be squeezed out of the pad (e.g., squeezed by compression from the absorbent core towards the first layer of the topsheet), such undesirable movement will be resisted by the first layer of the topsheet which has a relatively low surface energy to repel the fluid as it attempts to make its way out of the pad through the openings in the topsheet. That is, a surface energy gradient provides a thermodynamic barrier against fluid flow that can cause rewet.

With regard to the surface energy gradient according to the present invention, it is important to remember that the upper and lower bounds of any such gradient are relative with respect to one another, i.e., the regions of a multi-layer formed film ply whose interface defines a surface energy gradient need not be on different sides of the hydrophobic/hydrophilic spectrum. That is to say, a gradient may be established by two layers of diverse degrees of hydrophobicity or diverse degrees of hydrophilicity, and need not necessarily be established with regard to a hydrophobic layer and a hydrophilic layer. Notwithstanding the foregoing, it is presently preferred that the upper layer of the formed film ply have a comparatively low surface energy, i.e., that it be generally hydrophobic, in order to maximize the driving force imparted to the incoming fluid and minimize the overall wettability of the wearer-contacting layer.

An alternative topsheet orientation, shown in Figure 5, is one in which the fluid permeable web 500 includes a fluid permeable transport ply 530. The wearer contacting surface of the transport ply 530 is joined to the garment-facing hydrophilic layer 520 of the formed film ply 505. Methods of joining the transport ply 530 and the formed film ply 505 are presented below. Figure 6 shows a further alternative topsheet embodiment where the fluid permeable web 600 includes at least one intermediate layer 620 between the most exterior body contacting surface 610 and the most exterior garment-facing surface 640. If the web layers or surfaces comprise incompatible materials, then the intermediate layer 620 preferably is a tie layer. Preferred intermediate layer materials are discussed above.

The fluid permeable transport ply can be comprised of a variety of different materials or combinations thereof. Suitable transport ply materials include 1) apertured formed films 2) cloth-like formed films; 3) nonwovens; 4) wovens; and 5) tissue.

Suitable transport ply formed films are described in the following references: U.S. Pat. No. 3,929,135, issued to Thompson on Dec. 30, 1975; U.S. Pat. No. 4,324,246, issued to Mullane et al. on Apr. 13, 1982; U.S. Pat. No. 4,342,314, issued to Radel et al. on Aug. 3, 1982; U.S. Pat. No. 4,463,045, issued to Ahr et al. on Jul. 31, 1984; and U.S. Pat. No. 5,006,394, issued to Baird on Apr. 9, 1991. One especially preferred formed film is described in one or more of the above patents and marketed on sanitary napkins by the Procter & Gamble Company of Cincinnati, Ohio as "DRI-WEAVE".

Alternatively, cloth-like formed films may comprise the transport ply. Such films have a softer, more cloth-like feel. Cloth-like formed films are developed by providing the film surface with either microapertures (as described above), texture (described below), a treatment (described

below), or a combination thereof. Suitable cloth-like formed films are described in the following references: U.S. Pat. No. 4,609,518, issued to Curro et al. on Sep. 2, 1986; U.S. Pat. No. 4,681,793, issued to Linman et al. on Jul. 21, 1987; U.S. Pat. No. 4,772,444, issued to Curro et al. on Sep. 20, 1988; U.S. Pat. No. 4,778,644, issued to Curro et al. on Oct. 18, 1988; U.S. Pat. No. 4,878,825, issued to Mullane, Jr. on Nov. 7, 1989. The transport ply may also be comprised of any nonwoven or woven material capable of transporting blood, menses, and/or urine. Other materials not listed herein, but capable of transporting blood, menses, and/or urine, are included in the present invention.

Methods of Making

The polymeric formed film ply of the present invention may be processed using conventional procedures for producing multilayer films on conventional coextruded film-making equipment. In general, polymers can be melt processed into films using either cast or blown film extrusion methods both of which are described in Plastics Extrusion Technology—2nd Ed., by Allan A. Griff (Van Nostrand Reinhold—1976), which is hereby incorporated herein by reference. Cast film is extruded through a linear slot die. Generally, the flat web is cooled on a large moving polished metal roll (chill roll). It quickly cools, and peels off the first roll, passes over one or more auxiliary rolls, then through a set of rubber-coated pull or "haul-off" rolls, and finally to a winder.

In blown film extrusion the melt is extruded upward through a thin annular die opening. This process is also referred to as tubular film extrusion. Air is introduced through the center of the die to inflate the tube and causes it to expand. A moving bubble is thus formed which is held at constant size by simultaneous control of internal air pressure, extrusion rate, and haul-off speed. The tube of film is cooled by air blown through one or more chill rings surrounding the tube. The tube is next collapsed by drawing it into a flattened frame through a pair of pull rolls and into a winder.

A coextrusion process requires more than one extruder and either a coextrusion feedblock or a multi-manifold die system or combination of the two to achieve the multilayer film structure. US Patents 4,152,387 and 4,197,069, issued May 1, 1979 and April 8, 1980, respectively, both to Cloeren, which are hereby incorporated herein by reference, disclose the feedblock and multi-manifold die principle of coextrusion. Multiple extruders are connected to the feedblock which can employ moveable flow dividers to proportionally change the geometry

of each individual flow channel in direct relation to the volume of polymer passing through the flow channels. The flow channels are designed such that, at their point of confluence, the materials flow together at the same velocities and pressure, minimizing interfacial stress and flow instabilities. Once the materials are joined in the feedblock, they flow into a single manifold die as a composite structure. Other examples of feedblock and die systems are disclosed in Extrusion Dies for Plastics and Rubber, W. Michaeli, Hanser, New York, 2nd Ed., 1992, hereby incorporated herein by reference. It may be important in such processes that the melt viscosities, normal stress differences, and melt temperatures of the material do not differ too greatly. Otherwise, layer encapsulation or flow instabilities may result in the die leading to poor control of layer thickness distribution and defects from non-planar interfaces (e.g. fish eye) in the multilayer film.

An alternative to feedblock coextrusion is a multi-manifold or vane die as disclosed in aforementioned US Patents 4,152,387 and 4,197,069, as well as U.S. Patent No. 4,533,308, issued August 6, 1985 to Cloeren, hereby incorporated herein by reference. Whereas in the feedblock system melt streams are brought together outside and prior to entering the die body, in a multi-manifold or vane die each melt stream has its own manifold in the die where the polymers spread independently in their respective manifolds. The melt streams are married near the die exit with each melt stream at full die width. Moveable vanes provide adjustability of the exit of each flow channel in direct proportion to the volume of material flowing through it, allowing the melts to flow together at the same velocity, pressure, and desired width.

Since the melt flow properties and melt temperatures of polymers vary widely, use of a vane die has several advantages. The die lends itself toward thermal isolation characteristics wherein polymers of greatly differing melt temperatures, for example up to 175° F (80° C), can be processed together.

Each manifold in a vane die can be designed and tailored to a specific polymer. Thus the flow of each polymer is influenced only by the design of its manifold, and not forces imposed by other polymers. This allows materials with greatly differing melt viscosities to be coextruded into multilayer films. In addition, the vane die also provides the ability to tailor the width of individual manifolds, such that an internal layer can be completely surrounded by the outer layer leaving no exposed edges. The aforementioned patents also disclose the combined use of feedblock systems and vane dies to achieve more complex multilayer structures.

One of skill in the art will recognize that the size of an extruder used to produce the films of the present invention depends on the desired production rate and that several sizes of extruders may be used. Suitable examples include extruders having a 1 (2.5 cm) to 1.5 inch (3.7 cm) diameter with a length/diameter ratio of 24 or 30. If required by greater production demands, the extruder diameter can range upwards. For example, extruders having a diameter between about 2.5 inches (6.4 cm) and about 4 inches (10 cm) can be used to produce the films of the present invention. A general purpose screw may be used. A suitable feedblock is a single temperature zone, fixed plate block. The distribution plate is machined to provide specific layer thicknesses. For example, for a three layer film, the plate provides layers in an 80/10/10 thickness arrangement, a suitable die is a single temperature zone flat die with "flex-lip" die gap adjustment. The die gap is typically adjusted to be less than 0.020 inches (0.5 mm) and each segment is adjusted to provide for uniform thickness across the web. Any size die may be used as production needs may require, however, 10–14 inch (25–35 cm) dies have been found to be suitable. The chill roll is typically water-cooled. Edge pinning is generally used and occasionally an air knife may be employed.

For some coextruded films, the placement of a tacky hydrophilic material onto the chill roll may be necessary. When the arrangement places the tacky material onto the chill roll, release paper may be fed between the die and the chill roll to minimize contact of the tacky material with the rolls. However, a preferred arrangement is to extrude the tacky material on the side away from the chill roll. This arrangement generally avoids sticking material onto the chill roll. An extra stripping roll placed above the chill roll may also assist the removal of tacky material and also can provide for additional residence time on the chill roll to assist cooling the film.

Occasionally, tacky material may stick to downstream rolls. This problem may be minimized by either placing a low surface energy (e.g. Teflon®) sleeve on the affected rolls, wrapping Teflon® tape on the effected rolls, or by feeding release paper in front of the effected rolls. Finally, if it appears that the tacky material may block to itself on the wound roll, release paper may be added immediately prior to winding. This is a standard method of preventing blocking of film during storage on wound rolls. Processing aids, release agents or contaminants should be minimized. In some cases, these additives can bloom to the layer and reduce the surface energy (raise the contact angle) of the hydrophilic layer.

An alternative method of making the multi-layer films of the present invention is to extrude a web comprising a material suitable for one of the individual layers. Extrusion methods as may be known to the art for forming flat films are suitable. Such webs may then be laminated to form a multi-layer film suitable for formation into a fluid pervious web using the methods discussed below. As will be recognized, a suitable material, such as a hot melt adhesive, can be used to join the webs to form the multi-layer film. A preferred adhesive is a pressure sensitive hot melt adhesive such as a linear styrene isoprene styrene ("SIS") hotmelt adhesive, but it is anticipated that other adhesives, such as polyester or polyamide powdered adhesives, hotmelt adhesives with a compatibilizer such as polyester, polyamide or low residual monomer polyurethanes, other hotmelt adhesives, or other pressure sensitive adhesives could be utilized in making the multi-layer films of the present invention. Alternative methods of joining the webs to form the multi-layer film include, but are not limited to, ultrasonic bonding, thermal bonding, or any other suitable means as are known in the art.

In another alternative method of making the multi-layer formed film plies of the present invention, a base or carrier web can be separately extruded and one or more layers can be extruded thereon using an extrusion coating process to form a multi-layer formed film ply according to the present invention. Preferably, the carrier web passes under an extrusion die at a speed that is coordinated with the extruder speed so as to form a very thin film having a thickness of less than about 25 microns. The molten polymer and the carrier web are brought into intimate contact as the molten polymer cools and bonds with the carrier web. As noted above, a tie layer may enhance bonding between the layers. A tie layer is typically comprised of a polymeric material that is able to bond with both adjacent layers. Tie layers are joined to adjacent layers using bonding means including, but not limited to, chemical bonds, physical entanglement of polymeric chains, and combinations thereof. Contact and bonding are also normally enhanced by passing the layers through a nip formed between two rolls. The bonding may be further enhanced by subjecting the layer of the carrier web that is to contact the film to layer treatment, such as corona treatment, as is known in the art and described in Modern Plastics Encyclopedia Handbook, p. 236 (1994), which is hereby incorporated by reference.

The polymeric web can be provided with a texture by ring rolling, forming web film into structural elastic-like film (SELF-ing), embossing, creping, or any other suitable method known in the art. Surface texturing can be performed on the entire web, on individual plies, or on individual layers. Surface texturing can be performed at any stage of construction of the web: prior to joining ply layers; after joining ply layers; after joining plies; and after web is

completed. Surface texturing will provide the exterior surfaces of the web with a softer, more cloth-like texture, provide the web with a more cloth-like appearance, and increase the overall caliper of the web.

Suitable processes for ring rolling or "pre-corrugating" are described in U.S. Pat. No. 4,107,364 issued to Sisson on Aug. 15, 1978, U.S. Pat. No. 4,834,741 issued to Sabee on May 30, 1989, U.S. Pat. No. 5,167,897 issued to Weber et al. on Dec. 1, 1992, U.S. Pat. No. 5,156,793 issued to Buell et al. on Oct. 20, 1992, and U.S. Pat. No. 5,143,679 issued to Weber on Sep. 1, 1992. The disclosures of which are incorporated by reference.

Suitable methods of SELF-ing are described in U.S. Pat. No. 5,518,801 issued to Chappell et al. on May 21, 1996. The disclosure of which is incorporated by reference. Examples of suitable methods of SELF-ing include, but are not limited to, embossing by mating plates or rolls, thermoforming, high pressure hydraulic forming, and casting.

The surfaces of the polymeric web can be provided with a treatment by brushing, flocking, delamination of viscous melts from porous surfaces, printed hair, and or any other processes known by the artisan to cause web surfaces to become fibrilated. Treatment of web surfaces can be performed on any interior or exterior surface of the web: web exterior surfaces; individual ply surfaces; and individual layer surfaces. Interior treatment can be utilized to help adjacent surfaces better adhere to one another. Exterior treatment will cause the treated surface to become fibrilated thereby giving the web surface a softer, silkier touch. Treatment can be performed at any stage of construction of the web: prior to joining ply layers; after joining ply layers; after joining ply; and after the web is completed.

Examples of brushing are disclosed in PCT Publication WO 99/06623, issued to Calhoun, et al. on February 11, 1999, the disclosure of which is hereby incorporated herein by reference.

Examples of flocking are disclosed in PCT Publications WO 98/42289, issued to Chen, et al. on October 1, 1998, WO 98/36721, issued to Johansson, et al. on August 27, 1998, and European Patent 861,646, issued to Takai, et al. on September 2, 1998, the disclosures of each of said patents being incorporated herein by reference.

Examples of delamination of viscous melts from porous surfaces are disclosed in PCT Publication WO 99/06623, issued to Calhoun, et al. on February 11, 1999, the disclosure of which is hereby incorporated herein by reference.

Examples of printed hair are disclosed in U.S. Patent No. 5,670,110, issued to Dirk, et al. on September 23, 1997, the disclosure of which is hereby incorporated herein by reference.

Absorbent Article According to the Present Invention

As used herein, the term "absorbent article" refers to devices which absorb and contain body exudates, and, more specifically, refers to devices which are placed against or in proximity to the body of the wearer to absorb and contain the various exudates discharged from the body. The term "disposable" is used herein to describe absorbent articles which are not intended to be laundered or otherwise restored or reused as an absorbent article (i.e., they are intended to be discarded after a single use, and, preferably, to be recycled, composted or otherwise disposed of in an environmentally compatible manner). A "unitary" absorbent article refers to absorbent articles which are formed of separate parts united together to form a coordinated entity so that they do not require separate manipulative parts like a separate holder and pad.

A preferred embodiment of a unitary disposable absorbent article made in accordance herewith is the catamenial pad, sanitary napkin 800, shown in Figure 8. As used herein, the term "sanitary napkin" refers to an absorbent article which is worn by females adjacent to the pudendal region, generally external to the urogenital region, and which is intended to absorb and contain menstrual fluids and other vaginal discharges from the wearer's body (e.g., blood, menses, and urine). Interlabial devices which reside partially within and partially external to the wearer's vestibule are also within the scope of this invention.

It is to be understood that the overall size, shape, and/or configuration of the absorbent article, if any, into which fluid transport multi-layer formed film plies according to the present invention are incorporated, or utilized in conjunction with, have no criticality or functional relationship to the principles of the present invention. Such parameters, however, must be considered along with the intended fluid and intended functionality when determining appropriate multi-layer formed film ply configurations and appropriate orientation of surface energy gradients according to the present invention.

Sanitary napkin 800 is illustrated as having two layers such as first layer 800a, sometimes referred to as a wearer-contacting or facing layer, a body-contacting or facing layer or "body layer", and second layer 800b, sometimes referred to as a garment-facing or contacting layer, or "garment layer". The sanitary napkin 800 is shown in Figure 8 as viewed from its first layer 800a. The first layer 800a is intended to be worn adjacent to the body of the wearer. The second layer

800b of the sanitary napkin 800 (shown in Figure 9) is on the opposite side and is intended to be placed adjacent to the wearer's undergarment when the sanitary napkin 800 is worn.

The sanitary napkin 800 has two centerlines, a longitudinal centerline "L" and a transverse centerline "T". The term "longitudinal", as used herein, refers to a line, axis or direction in the plane of the sanitary napkin 800 that is generally aligned with (e.g., approximately parallel to) a vertical plane which bisects a standing wearer into left and right body halves when the sanitary napkin 800 is worn. The terms "transverse" or "lateral" as used herein, are interchangeable and refer to a line, axis or direction which lies within the plane of the sanitary napkin 800 that it generally perpendicular to the longitudinal direction. Figure 8 also shows that the sanitary napkin 800 has a periphery 840 which is defined by the outer edges of the sanitary napkin 800 in which the longitudinal edges (or "side edges") are designated 850 and the end edges (or "ends") are designated 860.

Figure 8 is top plan view of a sanitary napkin 800 of the present invention in a substantially flat state with portions of the sanitary napkin being cut away to more clearly show the construction of the sanitary napkin 800 and with the portion of the sanitary napkin 800 which faces or contacts the wearer 800a oriented towards the viewer. As shown in Figure 8, the sanitary napkin 800 preferably comprises a liquid pervious topsheet 805, a liquid impervious backsheet 810 joined with the topsheet 805, an absorbent core 820 positioned between the topsheet 805 and the backsheet 810, and a secondary topsheet or acquisition layer 830 positioned between the topsheet 805 and the absorbent core 820.

The sanitary napkin 800 preferably includes optional side flaps or "wings" 870 that are folded around the crotch portion of a wearer's panty. The side flaps 870 can serve a number of purposes, including, but not limited to helping to hold the napkin in proper position while protecting the wearer's panty from soiling and keeping the sanitary napkin secured to the wearer's panty.

Figure 9 is a cross-sectional view of the sanitary napkin 800 taken along section line 9-9 of Figure 8. As can be seen in Figure 9, the sanitary napkin 800 preferably includes an adhesive fastening means 880 for attaching the sanitary napkin 800 to the undergarment of the wearer. Removable release liners 890 cover the adhesive fastening means 880 to keep the adhesive from sticking to a layer other than the crotch portion of the undergarment prior to use.

The topsheet 805 comprises the apertured formed film web of the present invention as is described above so as to provide the comfort and fluid handling benefits of the present invention.

The topsheet 805 has a first layer 805a and a second layer 805b positioned adjacent to and preferably secured to a first layer 830a of the fluid acquisition layer 830 to promote fluid transport from the topsheet to the acquisition layer. The second layer 830b of the acquisition layer 830 is positioned adjacent to and is preferably secured to the first layer 820a of an absorbent core or fluid storage layer 820 to promote fluid transport from the acquisition layer to the absorbent core. The second layer 820b of the absorbent core 820 is positioned adjacent to and is preferably secured to the first layer 810a of the backsheet 810.

In addition to having a longitudinal direction and a transverse direction, the sanitary napkin 800 also has a "Z" direction or axis, which is the direction proceeding downwardly through the topsheet 805 and into whatever fluid storage layer or core 820 that may be provided. The objective is to provide a substantially continuous path between the topsheet 805 and the underlying layer or layers of the absorbent article herein, such that fluid is drawn in the "Z" direction and away from the topsheet of the article and toward its ultimate storage layer.

The absorbent core 820 may be any absorbent means which is capable of absorbing or retaining liquids (e.g., menses and/or urine). As shown in Figures 8 and 9, the absorbent core 820 has a body layer 820a, a garment facing layer 820b, side edges, and end edges. The absorbent core 820 may be manufactured in a wide variety of sizes and shapes (e.g. rectangular, oval, hourglass, dogbone, asymmetric, etc.) and from a wide variety of liquid-absorbent materials commonly used in sanitary napkins and other absorbent articles such as comminuted wood pulp which is generally referred to as airfelt. Examples of other suitable absorbent materials include creped cellulose wadding; meltblown polymers including coform; chemically stiffened, modified or cross-linked cellulosic fibers; synthetic fibers such as crimped polyester fibers; peat moss; tissue including tissue wraps and tissue laminates; absorbent foams; absorbent sponges; superabsorbent polymers; absorbent gelling materials; or any equivalent material or combination of materials, or mixtures of these.

The configuration and construction of the absorbent core may also be varied (e.g., the absorbent core may have varying caliper zones (e.g. profiled so as to be thicker in the center), hydrophilic gradients, superabsorbent gradients or lower density or lower average basis weight acquisition zones; or may comprise one or more layers or structures). The total absorbent capacity of the absorbent core, should, however, be compatible with the design loading and the intended use of the absorbent article. Further, the size and absorbent capacity of the absorbent core may be

varied to accommodate different uses such as incontinent pads, pantliners, regular sanitary napkins, or overnight sanitary napkins.

Exemplary absorbent structures for use as the absorbent core in the present invention are described in U.S. Patent No. 4,950,264 issued to Osborn on August 21, 1990; U.S. Patent No. 4,610,678 issued to Weisman et al. on September 9, 1986; U.S. Patent No. 4,834,735 issued to Alemany et al. on May 30, 1989; European Patent Application No. 0 198 683, the Procter & Gamble Company, published October 22, 1986 in the name Duenk et al.; and U.S. Patent No. Application Serial No. 60/128,352, filed in the name of Noel et al. April, 8, 1999. The disclosure of each of these patents is incorporated herein by reference.

The backsheet 810 and the topsheet 805 are positioned adjacent the garment facing layer and the body facing layer respectively of the absorbent core 820 and are preferably joined thereto and to each other by attachment means (not shown) such as those well known in the art. For example, the backsheet 810 and/or the topsheet 805 may be secured to the absorbent core or to each other by a uniform continuous layer of adhesive, a patterned layer of adhesive or any array of separate lines, spirals or spots of adhesive. Adhesives which have been found to be satisfactory are manufactured by H.B. Fuller Company of St. Paul, Minnesota under the designation HL-1258, and by Findlay of Minneapolis, Minnesota, under the designation H-2031. The attachment means will preferably comprise an open pattern network of filaments of adhesive as disclosed in U.S. Patent No. 4,573,986 issued to Minetola et al. on March 4, 1986, the disclosure of which is incorporated herein by reference. An exemplary attachment means of an open patterned network of filaments comprises several lines of adhesive filaments swirled into a spiral pattern such as illustrated by the apparatus and method shown in U.S. Patent No. 3,911,173 issued to Sprague, Jr. on October 7, 1975; U.S. Patent No. 4,785,996 issued to Zieker et al. on November 22, 1978 and U.S. Patent No. 4,842,666 issued to Werenicz on June 27, 1989. The disclosures of each of these patents are incorporated herein by reference. Alternatively, the attachment means may comprise heat bonds, pressure bonds, ultrasonic bonds, dynamic mechanical bonds or any other suitable attachment means or combinations of these attachment means as are known in the art.

Preferably, the topsheet 805 is sized to coincide with the backsheet 810 and joined thereto about the periphery 840 of sanitary napkin 800. The topsheet 805 and the backsheet 810 may be joined using means as are known to the art such as adhesive bonding, heat bonds, pressure bonds, ultrasonic bonds, dynamic mechanical bonds or any other suitable attachment means or

combinations of these attachment means as are known in the art. Preferably, the topsheet 805 and the backsheet 810 are joined using a combination of heat and pressure known as fusion bonding.

The backsheet 810 is impervious to liquids (e.g., menses and/or urine) and is preferably manufactured from a thin plastic film, although other flexible liquid impervious materials may also be used. As used herein, the term "flexible" refers to materials which are compliant and are more readily conformed to the general shape and contours of the human body. The backsheet 810 prevents the exudates absorbed and contained in the absorbent core from wetting articles which contact the sanitary napkin 800 such as undergarments and other articles of clothing. The backsheet 810 may thus comprise a woven or nonwoven material, formed film plies such as thermoplastic films of polyethylene or polypropylene, or composite materials such as a film-coated nonwoven material. Preferably, the backsheet of the polyethylene film having a thickness of from about 0.012 mm (0.5 mil) to about 0.051 mm (2.0 mil). Exemplary polyethylene films are manufactured by Clopay Corporation of Cincinnati, OH, under the designation P18-1401 and by Tredegar Film Products of Terre Haute, IN, under the designation XP-9818. The backsheet is preferably embossed and/or matte finished to provide a more cloth-like appearance. Further, the backsheet 810 may permit vapors to escape from the absorbent core 820 (i.e., breathable) while still preventing exudates from passing through the backsheet 810.

In use, the sanitary napkin 800 can be held in place by any support means or attachment means 880 well-known for such purposes. Preferably, the sanitary napkin is placed in the user's undergarment or panty and secured thereto by a fastener such as an adhesive. The adhesive provides a means for securing the sanitary napkin in the crotch portion of the panty. Thus, a portion or all of the outer or garment facing layer 810b of the backsheet 810 is coated with adhesive. Any adhesive or glue used in the art for such purposes can be used for the adhesive herein, with pressure-sensitive adhesives being preferred. Suitable adhesives are manufactured by H. B. Fuller Company of St. Paul, Minnesota, under the designation 2238. Suitable adhesive fasteners are also described in U.S. Patent No. 4,917,697. Before the sanitary napkin is placed in use, the pressure-sensitive adhesive is typically covered with a removable release liner 890 in order to keep the adhesive from drying out or adhering to a layer other than the crotch portion of the panty prior to use. Suitable release liners are also described in the above-referenced U.S. Patent No. 4,917,697. Any commercially available release liners commonly used for such purposes can be utilized herein. A non-limiting example of a suitable release liner is BL30MG-A SILOX 4P/O, which is manufactured by the Akrosil Corporation of Menasha, WI. The sanitary napkin 800 of the present invention is used by removing the release liner and thereafter placing the sanitary napkin in

a panty so that the adhesive contacts the panty. The adhesive maintains the sanitary napkin in its position within the panty during use.

In one preferred embodiment of the present invention, the sanitary napkin has two flaps 870 each of which are adjacent to and extend laterally from the side edge of the absorbent core. The flaps 870 are configured to drape over the edges of the wearer's panties in the crotch region so that the flaps are disposed between the edges of the wearer's panties and the thighs. The flaps serve at least two purposes. First, the flaps help serve to prevent soiling of the wearer's body and panties by menstrual fluid, preferably by forming a double wall barrier along the edges of the panty. Second, the flaps are preferably provided with attachment means on their garment layer so that the flaps can be folded back under the panty and attached to the garment facing side of the panty. In this way, the flaps serve to keep the sanitary napkin properly positioned in the panty. The flaps can be constructed of various materials including materials similar to the topsheet, backsheet, tissue, or combination of these materials. Further, the flaps may be a separate element attached to the main body of the napkin or can comprise extensions of the topsheet and backsheet (i.e., unitary). A number of sanitary napkins having flaps suitable or adaptable for use with the sanitary napkins of the present invention are disclosed in U.S. Patent No. 4,687,478, issued to Van Tilburg on August 18, 1987; and U.S. Patent No. 4,589,876, issued to Van Tilburg on May 20, 1986. The disclosure of each of these patents is hereby incorporated herein by reference.

In a preferred embodiment of the present invention shown in Figures 8 and 9, an acquisition layer(s) 830 is positioned between the topsheet 805 and the absorbent core 820. The acquisition layer 830 may serve several functions including improving wicking of exudates over and into the absorbent core. There are several reasons why the improved wicking of exudates is important, including providing a more even distribution of the exudates throughout the absorbent core and allowing the sanitary napkin 800 to be made relatively thin. The wicking referred to herein may encompass the transportation of liquids in one, two or all directions (i.e., in the x-y plane and/or in the z-direction). The acquisition layer may be comprised of several different materials including nonwoven or woven formed film plies of synthetic fibers including polyester, polypropylene, or polyethylene; natural fibers including cotton or cellulose; blends of such fibers; or any equivalent materials or combinations of materials. Examples of sanitary napkins having an acquisition layer and a topsheet are more fully described in U.S. Pat. No. 4,950,264 issued to Osborn. The disclosures of which is hereby incorporated herein by reference. In a preferred embodiment, the acquisition layer may be joined with the topsheet by any of the conventional means for joining formed film plies together, most preferably by fusion bonds.

A representative embodiment of a disposable absorbent article in the form of a diaper 900, is shown in Figure 10. As used herein, the term "diaper" refers to a garment generally worn by infants and incontinent persons that is worn about the lower torso of the wearer. It should be understood, however, that the present invention is also applicable to other absorbent articles such as incontinent briefs, training pants, diaper inserts, and the like. The diaper 900 depicted in Figure 10 is a simplified absorbent article that could represent a diaper prior to its being placed on a wearer. It should be understood, however, that the present invention is not limited to the particular type or configuration of diaper shown in Figure 10.

Figure 10 is a perspective view of the diaper 900 in its uncontracted state (i.e., with all the elastic induced contraction removed) with portions of the structure being cut-away to more clearly show the construction of the diaper 900. The portion of the diaper 900 which contacts the wearer faces the viewer. The diaper 900 is shown in Figure 10 to preferably comprise a liquid pervious topsheet 940; a liquid impervious backsheet 920 joined with the topsheet 940; and an absorbent core 960 positioned between the topsheet 940 and the backsheet 920. Additional structural features such as elastic members and fastening means for securing the diaper in place upon a wearer (such as tape tab fasteners) may also be included.

While the topsheet 940, the backsheet 920, and the absorbent core 960 can be assembled in a variety of well known configurations, a preferred diaper configuration is described generally in U.S. Patent No. 3,860,003 (Buell), issued January 14, 1975, the disclosure of which is incorporated by reference. Alternatively preferred configurations for disposable diapers herein are also disclosed in U.S. Patent No. 4,808,178 (Aziz et al), issued February 28, 1989; U.S. Patent No. 4,695,278 (Lawson), issued September 22, 1987; and U.S. Patent No. 4,816,025 (Foreman), issued March 28, 1989, the disclosures of each of these patents hereby being incorporated herein by reference.

Figure 10 shows a preferred embodiment of the diaper 900 in which the topsheet 940 and the backsheet 920 are co-extensive and have length and width dimensions generally larger than those of the absorbent core 960. The topsheet 940 is joined with and superimposed on the backsheet 920 thereby forming the periphery of the diaper 900. The periphery defines the outer perimeter or the edges of the diaper 900. The periphery comprises the end edges 910 and the longitudinal edges 930.

The backsheet 920 is generally that portion of the diaper 900 which prevents the exudates absorbed and contained therein from soiling articles which may contact the diaper 900, such as

bedsheets and undergarments. In preferred embodiments, the backsheet 920 is impervious to liquids (e.g., urine) and comprises a thin plastic film such as a thermoplastic film having a thickness of about 0.012 mm (0.5 mil) to about 0.051 mm (2.0 mils). Suitable backsheet films include those manufactured by Tredegar Industries Inc. of Terre Haute, IN and sold under the trade names X15306, X10962 and X10964. Other suitable backsheet materials may include breathable materials which permit vapors to escape from the diaper 900 while still preventing exudates from passing through the backsheet 920. Exemplary breathable materials may include materials such as woven webs, nonwoven webs, composite materials such as film-coated nonwoven webs, microporous films such as manufactured by Mitsui Toatsu Co., of Japan under the designation ESPOIR NO and by Exxon Chemical Co., of Bay City, TX, under the designation EXXAIRE, and monolithic films such as manufactured by Clopay Corporation, Cincinnati, OH under the name Hytrel® blend P18-3097. Some breathable composite materials are described in greater detail in PCT Application No. WO 95/16746, published on June 22, 1995 in the name of E. I. DuPont, U.S. Patent No. 5,865,823 issued on February 2, 1999 in the name of Curro, and U.S. Patent No. 5,571,096 issued to Dobrin et al. on November 5, 1996. Each of these references is hereby incorporated by reference herein.

The backsheet 920, or any portion thereof, may be elastically extensible in one or more directions. In one embodiment, the backsheet 920 may comprise a structural elastic-like film ("SELF") web as described in U.S. Patent No. 5,518,801, which issued to Chappell, et, al. on May 21, 1996, which is incorporated herein by reference. In alternate embodiments, the backsheet 920 may comprise elastomeric films, foams, strands, or combinations of these or other suitable materials with nonwovens or synthetic films.

The size of the backsheet 920 is dictated by the size of the absorbent core 960 and the exact diaper design selected. In a preferred embodiment, the backsheet 920 has a modified hourglass-shape extending beyond the absorbent core 960 a minimum distance of at least about 1.3 centimeters to about 2.5 centimeters (about 0.5 to about 1.0 inch) around the entire diaper periphery.

The topsheet 940 comprises the apertured formed film web of the present invention as is described above so as to provide the comfort and fluid handling benefits of the present invention. Preferably, the topsheet 940 is sized to coincide with the backsheet 920.

The topsheet 940 and the backsheet 920 are joined together in any suitable manner. As used herein, the term "joined" encompasses configurations whereby the topsheet 940 is directly joined

to the backsheet 920 by affixing the topsheet 940 directly to the backsheet 920, and configurations whereby the topsheet 940 is indirectly joined to the backsheet 920 by affixing the topsheet 940 to intermediate members which in turn are affixed to the backsheet 920. In a preferred embodiment, the topsheet 940 and the backsheet 920 are affixed directly to each other in the diaper periphery by attachment means (not shown) such as an adhesive or any other attachment means as known in the art. For example, a uniform continuous layer of adhesive, a patterned layer of adhesive, or an array of separate lines or spots of adhesive can be used to affix the topsheet 940 to the backsheet 920.

Tape tab fasteners (not shown for clarity) are typically applied to the back waistband region of the diaper 920 to provide a fastening means for holding the diaper on the wearer. The tape tab fasteners can be any of those well known in the art, such as the fastening tape disclosed in U.S. Patent No. 3,848,594 (Buell), issued November 19, 1974, the disclosure of which is hereby incorporated by reference. These tape tab fasteners or other diaper fastening means are typically applied near the corners of the diaper 900.

Elastic members (also not shown for clarity) are disposed adjacent the periphery of the diaper 900, preferably along each longitudinal edge 930, so that the elastic members tend to draw and hold the diaper 900 against the legs of the wearer. Alternatively, the elastic members can be disposed adjacent either or both of the end edges 910 of the diaper 900 to provide a waistband as well as or rather than leg cuffs. For example, a suitable waistband is disclosed in U.S. Patent No. 4,515,595 (Kievit et al), issued May 7, 1985, the disclosure of which is hereby incorporated by reference. In addition, a method and apparatus suitable for manufacturing a disposable diaper having elastically contractible elastic members is described in U.S. Patent No. 4,081,301 (Buell), issued March 28, 1978, the disclosure of which is hereby incorporated herein by reference.

The elastic members are secured to the diaper 900 in an elastically contractible condition so that in a normally unrestrained configuration, the elastic members effectively contract or gather the diaper 900. The elastic members can be secured in an elastically contractible condition in at least two ways. For example, the elastic members can be stretched and secured while the diaper 900 is in an uncontracted condition. Alternatively, the diaper 900 can be contracted, for example, by pleating, and the elastic members secured and connected to the diaper 900 while the elastic members are in their unrelaxed or unstretched condition. The elastic members may extend along a portion of the length of the diaper 900. Alternatively, the elastic members can extend the entire length of the diaper 900, or any other length suitable to provide an elastically contractible line. The length of the elastic members is dictated by the diaper design.

The elastic members can be in a multitude of configurations. For example, the width of the elastic members can be varied from about 0.25 millimeters (0.01 inches) to about 25 millimeters (1.0 inch) or more; the elastic members can comprise a single strand of elastic material or can comprise several parallel or non-parallel strands of elastic material; or the elastic members can be rectangular or curvilinear. Still further, the elastic members can be affixed to the diaper in any of several ways which are known in the art. For example, the elastic members can be ultrasonically bonded, heat and pressure sealed into the diaper 900 using a variety of bonding patterns or the elastic members can simply be glued to the diaper 900.

The absorbent core 960 of the diaper 900 is positioned between the topsheet 940 and the backsheet 920. The absorbent core 960 can be manufactured in a wide variety of sizes and shapes (e.g., rectangular, hourglass, asymmetrical, etc.). The total absorbent capacity of the absorbent core 960 should, however, be compatible with the design liquid loading for the intended use of the absorbent article or diaper. Further, the size and absorbent capacity of the absorbent core 960 can vary to accommodate wearers ranging from infants through adults.

As shown in Figure 10, the absorbent core 960 includes a fluid storage/distribution member 980. In a preferred configuration such as depicted in Figure 10, the absorbent core 960 preferably further includes an acquisition layer or member 990 in fluid communication with the fluid storage/distribution member 980 and located between the fluid storage/distribution member 980 and the topsheet 940. The acquisition layer or member 990 may be comprised of several different materials including nonwoven or woven formed film plies of synthetic fibers including polyester, polypropylene, or polyethylene, natural fibers including cotton or cellulose, blends of such fibers, or any equivalent materials or combinations of materials.

In use, the diaper 900 is applied to a wearer by positioning the back waistband region under the wearer's back, and drawing the remainder of the diaper 900 between the wearer's legs so that the front waistband region is positioned across the front of the wearer. The tape-tab or other fasteners are then secured preferably to outwardly facing areas of the diaper 900.

EXAMPLE

This example demonstrates the extrusion and aperturing of an apertured web comprising a three layer formed film ply having permanent hydrophilicity according to the present invention.

Extrusion Apparatus

A typical extrusion apparatus for a three layer film uses three extruders, a fixed plate feedblock, a single manifold flat die, and a cast film line. A description of each piece of equipment used to make film samples is provided below:

Extruders: Two sizes of extruders were used. The thick hydrophobic layer was extruded by a 1 ¼ inch diameter, 30 L/D ("length to diameter ratio), extruder while the thinner hydrophilic and tie layers were extruded by 1 inch diameter, 24 L/D, extruders. A general purpose screw was used in all extruders having 8 sections of feed, 8 sections of transition, 8 sections of metering and a compression ratio of 2 ½ to 1.

Adapting Piping: The piping that connected the extruders to the feedblock was less than 24" in length. The piping temperatures were maintained at the same temperatures as the metering zone of each respective extruder.

Feedblock: The feedblock was a one temperature zone, fixed plate block. The distribution plate was machined for 80/10/10 % layering. The 80% outer layer was oriented toward the chill roll.

Die: A 14 inch (35 cm) coathanger die with a flex-lip die gap was used. A suitable die is available from Killion Extruders of Cedar Grove, NJ.

Cast Film Line: A 12 to 16 inch wide cast film line with layer speeds up to 100 feet per minute was used. The chill roll is typically cooled by city water at temperatures between 45 and 75°F (7–24°C) and the film edge was fixed by edge pinning. Typical layer speeds are 50 to 70 fpm to produce a 1.0 mil (25µ) film.

Materials

Hytrel Resins: Hytrel® HTR 8171 and Hytrel® HTR 8206 from E. I DuPont of Wilmington, DE

Tie Layer: Bynel® 3860 from DuPont

Polyethylene: X-8318 resin from Tredegar Film Products of Richmond, VA

Processing of Materials

Material Preparation: Hytrel resins were either dried overnight at 175°F (79°C) in a dehumidifying drier (or for material recently received from the

manufacturer dried at 230°F (110°C) for 2 to 4 hours). Then a blend of Hytrel® HTR 8171 and Hytrel® HTR 8206 was physically blended or tumbled immediately prior to feeding the extruder hopper. Polyethylene and Bynel tie layer resins were used directly from their containers without drying or other special handling.

Extrusion Conditions Coextrusions were run at the following temperatures. The temperatures were selected to minimize edge encapsulation.

Zone Temperature (°F/°C)			
Material	Feed	Plasticizing	Meter
Hytrel	320/160	350/177	380/193
Tie Layer	250/120	390/199	400/204
PE	350/177	400/204	440/227
Feedblock / Die	420/216		

A coextruded three layer film having a hydrophilic layer comprising equal parts of Hytrel® HTR 8171 and Hytrel® HTR 8206, a tie layer comprising Bynel® 3860, and an opacified polyethylene layer was extruded using the apparatus described above and the following specific setup parameters to form a 1 mil (25μ) film.

	<u>Hytrel Extruder</u>	<u>Tie Layer Extruder</u>	<u>PE Extruder</u>
Screw Diameter (in/mm.)	1/25	1/25	1¼/31
Screw Speed (rpm)	10.5	11.5	77
Pressure (psi)	8000	1375	3240

The resulting film has a Hytrel®/tie layer/polyethylene layer weight ratio of 10/10/80 and a thickness of 1 mil (25μ).

Film Aperturing

The extruded trilayer film comprising a polyethylene layer, a Bynel® 3860 layer and a 50/50 Hytrel® HTR 8171/Hytrel® HTR 8206 layer (80/10/10 layer weight ratio) described above is hydroformed on a 100-mesh screen with holes approximately 7 mil in diameter, under a water pressure of approximately 1,000 pounds per square inch (psi), at a temperature of 160° Fahrenheit (F), and at a rate of 20 fpm.

The three dimensional surface structures made in this way are cone-shaped with dimensions of approximately 3-7 mil diameter and 5-7 mil height. The film is soft to the touch and has good fluid handling properties.

ANALYTICAL METHODS

The following are representative analytical methods which have been found suitable for and useful in determining the performance of fluid transport formed film plies in accordance with the present invention.

1. Water Contact Angle

The contact angle formed between the solid layer of an unapertured film and the meniscus of a water drop is a measure of solid substrate hydrophilicity/hydrophobicity. The lower the water contact angle, the higher the substrate hydrophilicity. The method described below is used for water contact angle measurement and more specifically used to define degree of hydrophilicity or hydrophobicity in accordance with the present invention.

A model NRL Goniometer (Rame-Hart, Inc., Mountain Lake, NJ) may be used to measure water contact angle. The water contact angle is typically measured in a room held at a temperature of 73°F (23°C) and a 50% relative humidity. A 4 µL droplet of deionized water is placed on a flat film (i.e., unapertured) sample sitting on the goniometer platform to measure contact angle at room temperature.

The goniometer is calibrated according to the following procedure:

1. Level the instrument using a bubble level to ensure that the sample platform is level.
2. Adjust the instrument light such that the droplet is clearly visible.
3. Place a 4 µL droplet of deionized water on a 3/8 in. thick piece of Lexan®. (available from General Electric) which has been previously washed with methanol and allowed to dry completely.
4. Measure the contact angle of the drop.

The instrument is properly calibrated if the contact angle of water on Lexan fills within the range of 68 ± 3 degrees.

Sample measurements are obtained according to the following procedure:

1. A representative sample is cut from an unapertured film, the sample having dimensions of approximately 2.5 cm x 5 cm.
2. The sample is placed on the sample platform. Double sided adhesive tape is used, to secure the sample on the platform and keep the sample flat.

3. A 4 μ L droplet of deionized water is placed onto the sample.
4. The position of the platform is adjusted (vertically and horizontally and focused to get a clear view of the droplet.
5. The contact angle is measured and recorded after the water droplet has been on the sample for 3 minutes, to ensure equilibration of the sample.
6. Steps 1-5 are repeated 3 times for each sample tested.
7. The average contact angle for each sample is calculated.

The disclosures of all patents, patent applications (and any patents which issue thereon, as well as any corresponding published foreign patent applications), and publications mentioned throughout this description are hereby incorporated by reference herein. It is expressly not admitted, however, that any of the documents incorporated by reference herein teach or disclose the present invention.

While various embodiments and/or individual features of the present invention have been illustrated and described, it would be obvious to those skilled in the art that various other changes and modifications can be made without departing from the spirit and scope of the invention. As will be also be apparent to the skilled practitioner, all combinations of the embodiments and features taught in the foregoing disclosure are possible and can result in preferred executions of the invention. It is therefore intended to cover in the appended claims all such changes and modifications that are within the scope of this invention.

WHAT IS CLAIMED IS:

1. A fluid permeable web that is suitable for use as a topsheet on an absorbent article, said web characterized by:

a polymeric formed film ply having a texture and comprising at least two layers, each of said layers having opposed first and second surfaces, wherein one of said first surfaces comprises a first exterior surface and one of said second surfaces comprises a second exterior surface;

said polymeric formed film ply is provided with microapertures placing said first exterior surface and said second exterior surface in fluid communication with one another; and

said first exterior surface and said second exterior surface are comprised of materials that provide a surface energy gradient between the surfaces.
2. The fluid permeable web of Claim 1, wherein at least one of said exterior surfaces is comprised of a hydrophilic block copolymer, wherein said hydrophilic block copolymer comprises blocks of a polyester and another polymer selected from the group consisting of a polyester, a polyamide, and a polyurethane.
3. The fluid permeable web of either Claim 1 or 2, said web further comprising:

a hydrophilic, fluid permeable transport ply; and

wherein said transport ply is joined to one of said exterior surfaces of said polymeric formed film ply.
4. The fluid permeable web of Claim 3, wherein said transport ply is provided with a texture.
5. The fluid permeable web of any one of the preceding Claims, wherein said fluid permeable web further comprises at least one intermediate layer between said layers.
6. The fluid permeable web of any one of the preceding Claims, wherein at least one of said surfaces is provided with a treatment.
7. A method of making a fluid permeable web that is suitable for use as a topsheet of an absorbent article, the method comprising the steps of:
 - a) providing at least two polymeric materials;

- b) melting each of said polymeric materials;
 - c) passing said melted polymeric materials through extrusion die orifices to form individual layers of polymeric film;
 - d) joining said layers of polymeric film to form a multi-layer polymeric web having multiple surfaces with a surface energy gradient between at least two of the surfaces;
 - e) continuously supporting said web on a forming structure, said forming structure having opposed surfaces and exhibiting a multiplicity of microapertures which place the opposed surfaces of said forming structure in fluid communication with one another, said forming structure moving in a direction parallel to the direction of travel of said web of film and carrying said web of film in said direction;
 - f) substantially continuously applying a fluid pressure differential across the thickness of said web of film along said direction of movement of said forming structure exhibiting said apertures, said fluid pressure differential being sufficiently great to cause said web of film to be urged into substantial conformance with said forming structure causing said web to rupture in those areas coinciding with said microapertures in said forming structure; and
 - g) providing said multi-layer microapertured polymeric web with a texture.
8. A method according to claim 7 wherein step d is selected from the group consisting of co-extrusion, extrusion coating, and lamination.
9. A method according to either Claim 7 or 8 wherein said texture is provided after step d.
10. A method according to Claim 9 wherein said method comprises the additional step of providing at least one exterior layer of said multi-layer polymeric web with a treatment.

1/4

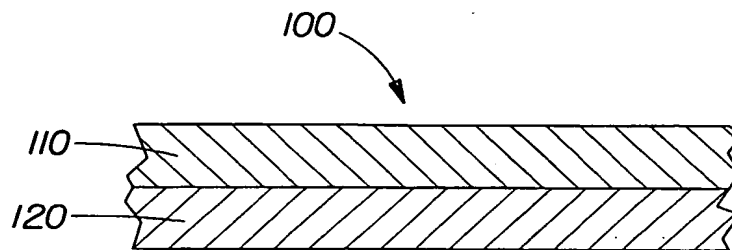


Fig. 1

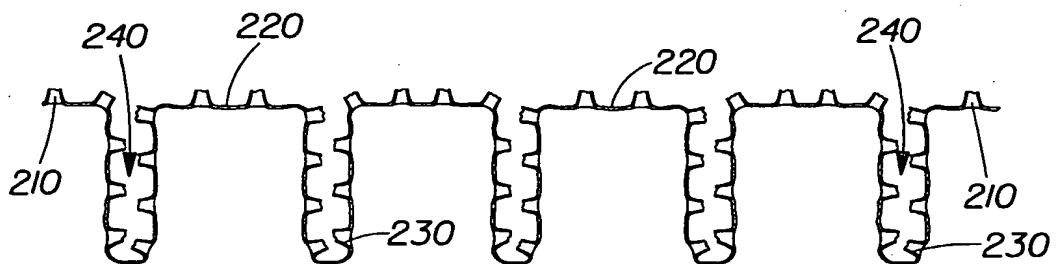


Fig. 2

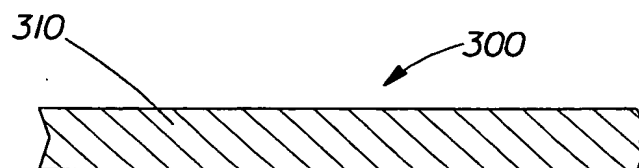


Fig. 3

2/4

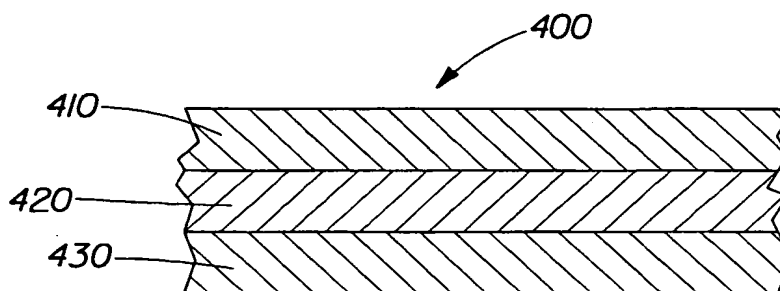


Fig. 4

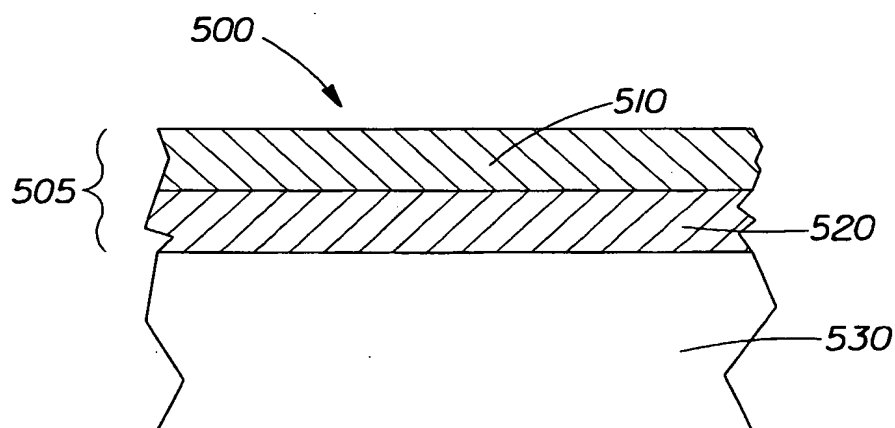


Fig. 5

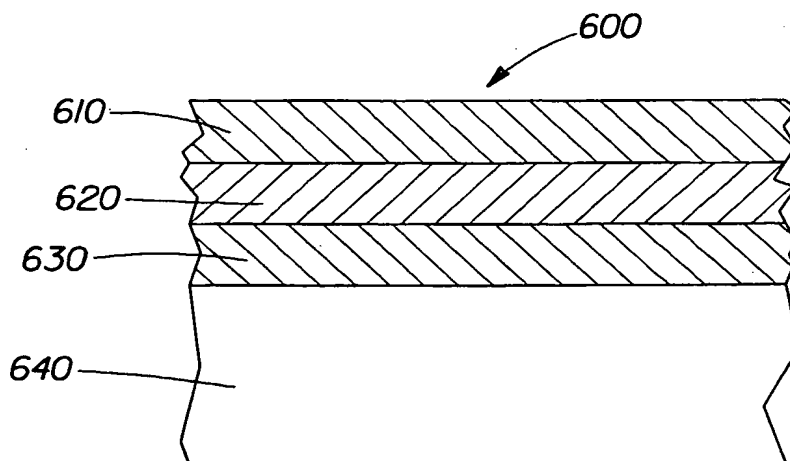


Fig. 6

3/4

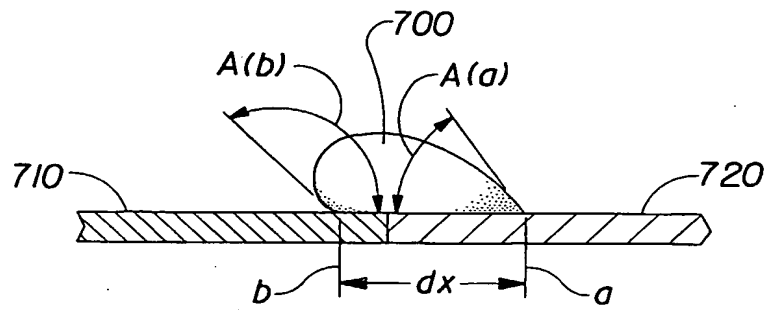


Fig. 7

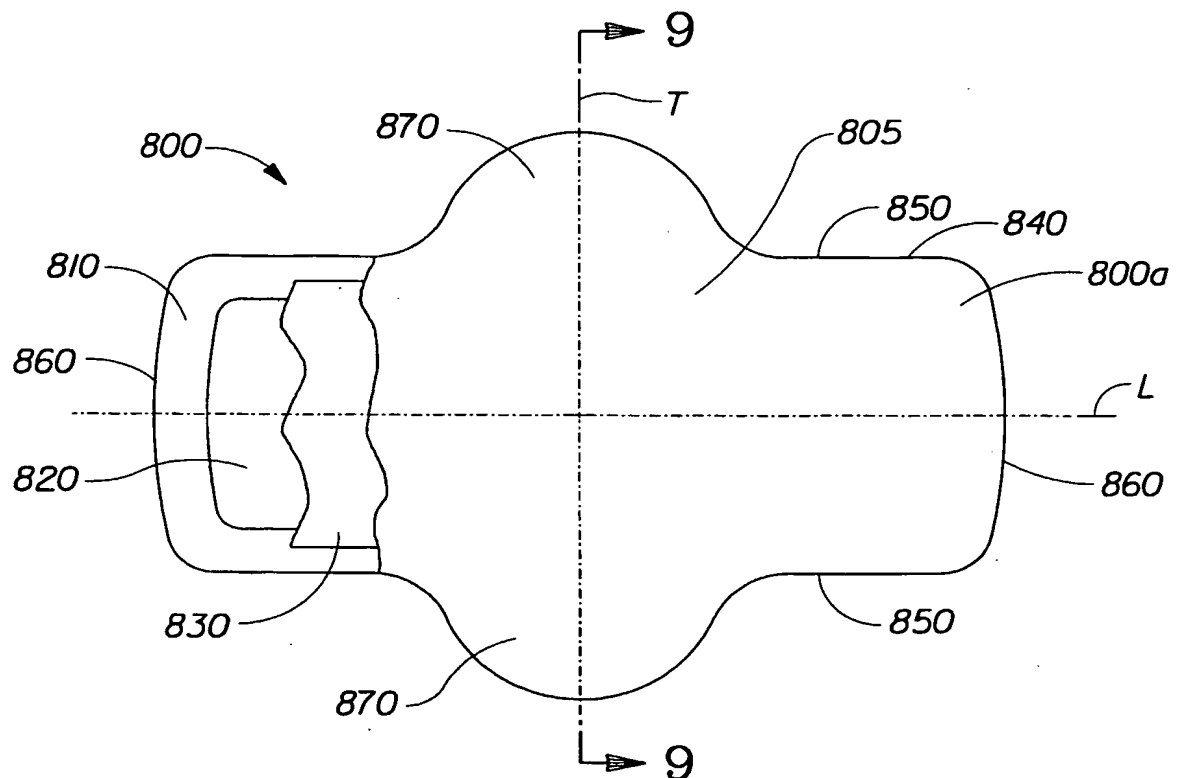


Fig. 8

4 / 4

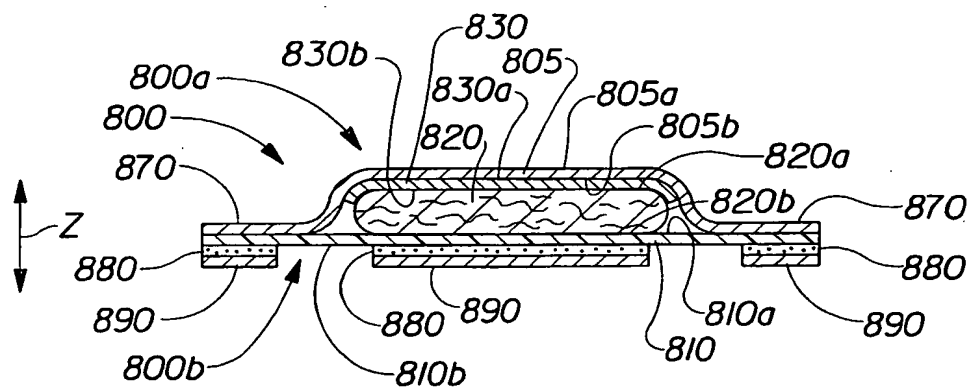


Fig. 9

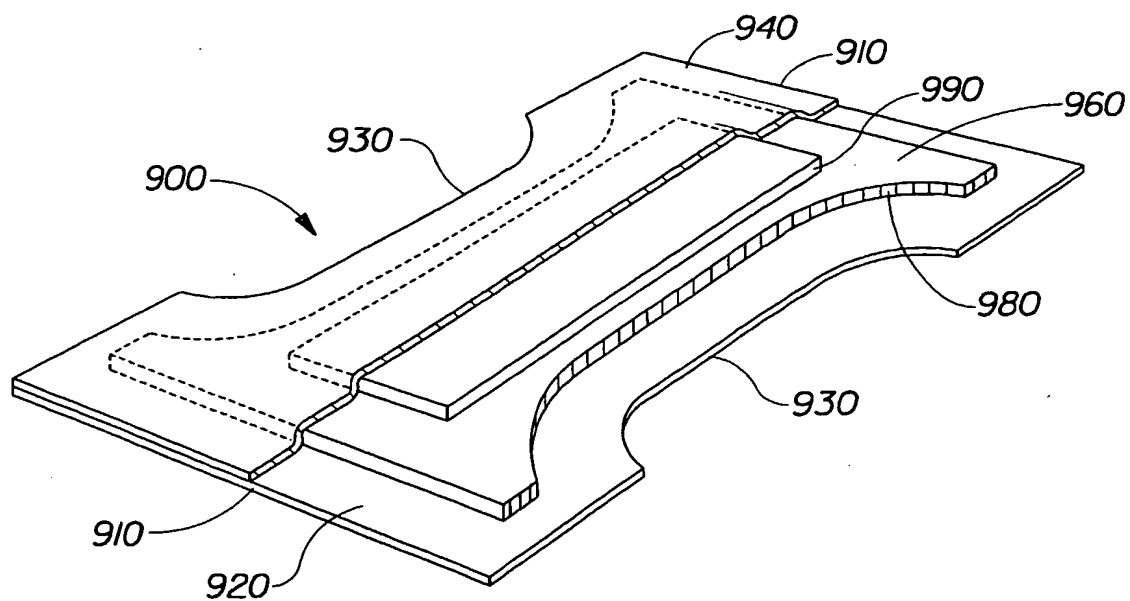


Fig. 10

INTERNATIONAL SEARCH REPORT

International Classification No
PCT/US 01/11394

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 A61F13/511

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 A61F A61L C08J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, PAJ, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Y	---	2
Y	DATABASE WPI Section Ch, Week 198427 Derwent Publications Ltd., London, GB; Class A23, AN 1984-166882 XP002176088 & JP 59 088902 A (TEIJIN LTD), 23 May 1984 (1984-05-23) abstract	2
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☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents:

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Date of the actual completion of the international search

29 August 2001

Date of mailing of the international search report

10/09/2001

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Mirza, A

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